# *Information*

# Elementary Electricity Motor Car Electric Systems *and* Delco Light

BOOK No. 1

*REVISED BY*
*HARVEY E. PHILLIPS*

PRICE 40 CENTS

Auto Electric Systems Pub. Co.
DAYTON, OHIO

# *Information*

## Elementary Electricity
## Motor Car Electric Systems
## and Delco Light

Revised by
HARVEY E. PHILLIPS



Auto Electric Systems Pub. Co.
DAYTON, OHIO

## CONTENTS

*Im*

**Elemen**
**Moto**

**I**

**Auto El**

the distance through which it travels. In a similar way we may say that electricity exists in a state of no pressure, but we can give to it a pressure by means of a generator, and when we allow the electricity to escape, as we may term it, it gives up its pressure, then it is, like water, giving up energy and doing work.

The amount of work that can be done depends upon the pressure and the rate current flows. We know that electricity is invisible, yet there is pressure behind it in one state and it flows under this pressure. We cannot measure the rate of flow in gallons per hour as we do in a water system; instead, we measure the rate it flows in amperes. We have said that electricity to flow must have pressure behind it to cause it to flow. In a water system water flows under a certain number of pounds pressure. In an electric system current flows under a certain number of volts pressure.

When a wire or any substance is used to transmit current from one place to another it is called a conductor. These conductors offer a resistance to the flow of an electric current therefore, we must have some means of measuring this resistance. The resistance offered to the flow of current depends upon the kind of metal used as a conductor, its area and length. The three terms just mentioned—the **volt** as the unit of electric pressure, the **ampere** as the unit of electric current and the **ohm** as the unit of electric resistance are related to one another—this relationship being known as Ohm's law. See Ohm's Law.

When we speak of electricity we should regard it as a means by which energy can be transmitted from one place to another. Energy exists in nature in various forms, such as coal, crude oil (from which gasoline, kerosene, etc., are derived), natural gas, etc., and by using up some of this "stored" energy, work can be done. All mechanical and electrical devices are simply "energy transformers." They are operated by energy in one of its forms, and during the time work is being done the energy is changed into another form.

For example:—A gasoline engine will run only as long as the supply of energy (in the form of gasoline) lasts. When this supply runs out, the engine stops. Part of the original energy is changed into a form of energy called heat, which is gradually absorbed by the air and objects with which the heat comes in contact. This represents a wasted

or lost part of the original energy. Part of the energy is changed into mechanical motion (which is simply energy in another form), by the action of the piston, connecting rod, crankshaft, etc. This represents the useful part of the original energy, and this in turn can again be changed into other forms by using it up in operating various machines, both mechanical and electrical. When a generator is driven, the power necessary to drive it is obtained from the energy transmitted through the crank shaft of the engine. The energy is thus transformed into another form which we call electricity, or rather electricity is generated and by means of the electricity, energy can be transmitted from the generator to any desired point by means of suitable conductors (wires).

By the use of an electric motor, the energy transmitted by electricity can again be changed into a mechanical form and used to drive various mechanical machines. Or, the energy transmitted by the electricity can be changed into the form of heat, and when the heat is made use of in an electric lamp we obtain light.

Energy may also exist, and be stored in a chemical form. Explosives, such as gunpowder, nitro-glycerine, etc., are examples of stored energy with which everyone is familiar.

A Storage Battery is simply a device in which energy can be stored in a chemical form. When a current of electricity is caused to flow through a storage battery, the energy transmitted by the electricity is used up in causing a chemical change to take place in the plates and electrolyte inside of the cells. This change is not permanent, however, and if the terminals of the battery are connected together to form a circuit (after the charging wires are disconnected) the chemical action will be reversed, and the stored energy liberated. A current of electricity will then flow out of the battery, and the energy thus liberated can be transmitted by means of the current, to any desired point.

The amount of energy that can be taken from a Storage Battery is always somewhat less than the amount required to charge it.

## MECHANICAL TERMS AND MEASUREMENTS

Before going very far into the subject of electricity and its uses we must understand something about the underlying principles of work performed mechanically. The meaning

of the words used is of the greatest importance, and these should be carefully studied first of all.

Work means in its simplest form, the lifting of a weight. The quantity of work done depends upon two things: First, the quantity of weight, and second, the distance through which the weight is to be lifted.

When we know these two things we can figure how much work has to be done. In order to measure the amount of work done it is necessary first of all to establish a standard of measurement of weight and also a standard of measurement of distance. The pound is therefore used as the unit or standard of measurement of weight, and the foot is used as the standard of measurement of distance. When a weight of one pound is lifted through a vertical distance of one foot, a definite amount of work has been done. This we would term the unit of measurement of the amount of work done.

When a weight of one pound is lifted through a vertical distance of one foot, we say that one foot pound of work has been done.

If the weight is allowed to fall through a distance of one foot, it performs an amount of work equal to one foot pound.

If the weight when lifted is placed on a support, it does not perform any work as long as it remains there. It must be allowed to fall from a high to a lower level before it can do any work. This brings out the very important fact that the weight must be in motion before any work can be done.

By lifting the weight we have stored up energy in it, and the energy is liberated when the weight is allowed to fall back to its original position. Work and energy therefore are very closely related to one another.

Energy simply means the capacity or ability to perform work.

The amount of work required to lift any weight to a definite height is measured by taking the weight in pounds and the distance in feet, and multiplying these two numbers together. For example: If a weight of ten pounds is raised to a height of five feet, the amount of work necessary to do this is 10x5, or 50 foot pounds.

In this way we are able to measure the amount of work done just as accurately as we can measure out the weight of anything, or the distance between two points.

When a weight is placed upon a table it exerts a force, or pressure upon the table which is equal to the weight itself. For example: A weight of ten pounds exerts a force or pressure equal to ten pounds upon the table. It is important, therefore, to remember that a force or pressure, acting upon a body and causing it to move, performs work. When a certain amount of work is to be done it makes no difference in the amount of work—whether we take one minute or one second to do it. Using the example given above, if the weight of ten pounds has to be raised to a height of five feet, fifty foot pounds of work are required to do it. Taking longer to do the work, makes it easier, but it does not decrease in any way the amount of work that has to be done.

When time is taken into consideration in connection with the doing of work, it determines the rate at which work is done. The rate determines the power required.

If ten pounds is raised five feet in one second, we say that the work is being done at the rate of fifty foot pounds per second. If the same amount of work is done in two seconds, the rate of doing it will be half of the rate necessary when the time was one second. We would, therefore, say that in the second case the work is done at the rate of twenty-five foot pounds per second.

In figuring power or the rate of doing work, it is customary to use the second as the unit of time used. The unit of measurement of power therefore is obtained by using the pound as the unit of weight, the foot as the unit of distance, and the second as the unit of time.

For example: When a one pound weight is lifted a height of one foot in one second, the rate of doing this is one foot pound per second.

This unit, however, is very small and when we wish to mention large quantities of power, a larger unit must be used. We say, therefore, that when work is done at the rate of 550 foot pounds per second, the power or rate of doing this work equals one Horse Power (H. P.).

The term H. P. is used in connection with the doing of work as a means of measuring the rate at which work is done.

The doing of 550 foot pounds of work in one second may be arrived at in many ways. For example: Ten pounds raised 55 feet equals 550 foot pounds, and if this has to be done

in one second, it requires one H. P. to do it. Similarly, 55 pounds raised ten feet equals 550 foot pounds. Also, eleven pounds raised 50 feet equals 550 pounds, and 550 pounds raised one foot equals 550 foot pounds.

If the time taken to do the work in each case is one second, the power required is one H. P.

Example:—How many Horse Power would be necessary to raise a weight of 500 lbs. to a height of 110 ft. in 20 seconds?

The total amount of work to be done is 500 times 110, or 55,000 ft. lbs. This has to be done in 20 seconds, so we divide 55,000 by 20. This equals 2,750 foot lbs. per second.

When work is done at the rate of 550 foot lbs. per second one Horse Power is required, so dividing 2,750 by 550 gives the number of H. P. required to do 2,750 foot pounds of work every second.

2,750 divided by 550 equals 5 H. P.

Note, that if the work had to be done in 10 seconds, which is half the time, the answer would be 10 H. P., which is equal to twice the rate of doing the work.

## ELECTRICAL TERMS AND MEASUREMENTS

Many people aproach the subject of electricity with fixed ideas that it is going to be very difficult to understand. Possibly they imagine that they never will be able to know anything about it.

While this is true, regarding the nature of electricity, it is by no means true in regard to its operation. If the fundamental principles of mechanical work are properly understood, the subject of electricity will not present many difficulties.

Electricity may be regarded as a means by which work can be done, or putting it in another way, energy can be transmitted from one place to another by means of electricity.

Electricity can also be used to store energy in a chemical manner as described elsewhere in this book.

The energy obtained from a steam or gas engine may be transmitted to any other piece of machinery, by means of gears or belts. In this way energy is transmitted from one place to another.

We can regard electricity as the "belt" which transmits the power from the engine to the machine that has to be driven.

Electricity is usually regarded as something that is capable of motion, or, to put it in another way, we say that electricity flows much in the same way as water. Instead of using pipes, however, as in the case of water, we have to use conductors (wires) to enable the electricity to flow from one place to another.

The term used in measuring the rate of flow of electricity is the ampere. It must always be remembered that current measured in amperes does not indicate quantity of electricity, but, the rate at which the current is flowing.

The meaning of the word ampere does not have to be considered any more than we have to consider the meaning of the word pound.

If we assume that electricity flows, there must be some force or pressure causing the electricity to flow. This force cannot be measured in pounds pressure per sq. inch, as in the case of steam or water. It is measured in volts. The volt is the unit of measurement of electrical pressure.

To measure the power produced electrically, it is only necessary to measure, first, the pressure in volts, and second, the rate of flow in amperes.

Then multiply the volts by the amperes (volts times amperes equals watts).

Example:—If the volt mete shows the pressure to be 32 volts and the ammeter shows the rate of flow of current to be 2 amperes, multiplying 32 volts by 2 amperes, gives 64 watts.

Electrically, power is measured in watts.

A watt is a very small unit of power and when larger quantities of power have to be measured, we use a larger unit than the watt. 1000 watts equals one kilowatt, and this is used in just the same way that we measure a certain distance in inches or feet, and larger distances are measured in miles.

When work is done at the rate of one watt for one hour of time, the amount of work done is called one watt hour. This can be illustrated in the following way.

If a man walks at the rate of four miles per hour for one hour, the distance covered is four miles. The mere statement that a man is walking at the rate of four miles per hour does not tell us how far he will walk. We must know how long he will walk at the rate of four miles per hour, before we can say how far he will go. When work is being done at a 1000 watt rate, the amount of work done in one hour is called one kilowatt hour.

There is a relation between mechanical power and electrical power which every one should remember. 746 watts, or in round numbers, 750 watts, equals one H. P. A Kilowatt, therefore, equals 1⅓ H. P. and one H. P. equals ¾ of a kilowatt.

Using this relation between H. P. and kilowatts we can easily change kilowatts to H. P. or H. P. to kilowatts.

The kilowatt hour (usually written K. W. H.) is the unit of measurement of quantity used in figuring the cost of power either produced or used.

Electric Light and Power Companies charge so much per K. W. H. for the use of electricity.

## OHMS LAW

Volts divided by Amperes equals Ohms.

Volts divided by Ohms equals Amperes.

Amperes multiplied by Ohms equals Volts.

## WATT LAW

Watts divided by Amperes equal Volts.

Watts divided by Volts equals Amperes.

Volts multiplied by Amperes equals Watts.

Q:—If current under 110 volts pressure flows through a circuit at a 10 Ampere rate, what is the resistance of the circuit? A:—110 (Volts) divided by 10 (Amperes) equals 11 Ohms resistance.

Q:—If current under 32 Volts pressure flows through a circuit at a 4 Ampere rate, what is the resistance of the circuit? A:—32 (Volts) divided by 4 (Amperes) equals 8 Ohms resistance.

Q:—The resistance of a circuit is 24 Ohms and the pressure upon the current flowing is 32 Volts. What is the rate

of flow of current in Amperes? A:—32 (Volts) divided by 24 (Ohms) equals 1⅓ Amperes.

Q:—The resistance of a circuit is 55 Ohms and current flows at a 2 Ampere rate. What is the pressure upon the current in volts? A:—2 Amperes) multiplied by 55 (Ohms) equals 110 Volts.

Q:—The resistance of a circuit is 16 Ohms and current flows at a 2 Ampere rate. What is the pressure upon the current in Volts? A:—2 (Amperes) multiplied by 16 (Ohms) equals 32 Volts.

Q:—If current under 100 Volts pressure is being consumed at the rate of 1100 Watts per hour, what is the rate of flow in Amperes? A:—1100 (Watts) divided by 110 (Volts) equals 10 Amperes.

Q:—If current under 32 Volts pressure is being consumed at the rate of 352 Watts per hour, what is the rate of flow in Amperes? A:—352 (Watts) divided by 32 (Volts) equals 11 Amperes.

Q:—Current under 110 Volts pressure is flowing through a circuit at a 5 Ampere rate. How many Watts will be consumed in 4 hours? A:—110 (Volts) multiplied by 5 (Amperes) equals 550 Watts per hour. 550 (Watts) multiplied by 4 (hours) equals 2200 Watts.

Q:—Current under 32 Volts pressure is flowing through a circuit at a 7 Ampere rate. How many Watts will be consumed in 4 hours? A:—32 (Volts) multiplied by 7 (Amperes) equals 224 Watts per hour. 224 (Watts) multiplied by four (hours) equals 896 Watts.

Q:—Current flowing through a circuit at a 5 Ampere rate is being consumed at the rate of 550 Watts per hour. What is the pressure in volts? A:—550 (Watts) divided by 5 (Amperes) equals 110 Volts.

Q:—Current is flowing through a circuit at a 9 Ampere rate and is being consumed at the rate of 288 Watts per hour. What is the pressure in Volts? A:—288 (Watts) divided by 9 (Amperes) equals 32 Volts.

Q:—If a 110 Volt motor consumes current at an 8-Ampere rate, how many Watts will be consumed in 5 hours? A:—110 (Volts) multiplied by 8 (Amperes) equals 880 Watts per hour. 880 (Watts) multiplied by 5 (Hours) equals 4400 Watts.

Q:—If a 110 Volt motor consumes current at a 10 Ampere rate, how may Kilowatts will be consumed in 10 hours? A:—110 (Volts) multiplied by 10 (Amperes- equals 1100 Watts per hour. 1100 (Watts) multiplied by 10 (Hours) equals 11,000 Watts. 11,000 (Watts) divided by 1000 (1000 Watts equal one Kilowatt) equals 11 Kilowatts.

—Q:—If a 32 Volt motor consumes current at a 10 Ampere rate, and current costs 3 cents per Kilowatt, what will it cost to operate it for 100 hours? A:—32 (Volts) multiplied by 10 (Amperes) equals 320 Watts per hour. 320 (Watts) multiplied by 100 (Hours) equals 32,000 Watts. 32,000 divided by 1000 equals 32 Kilowatts. 32 Kilowatts at 3c per Kilowatt equals 96 cents.

Q:—If twelve 32 Volt lamps consume current at a 24 Ampere rate, what is the average Wattage per lamp? A:—24 (Amperes) divided by 12 (Lamps) equals 2 Amperes per lamp. 2 (Amperes) multiplied by 32 (Volts) equals 64 Watts per lamp.

Q:—What will it cost to burn five 50 Watt lamps three hours per night for 30 nights if current costs 9 cents per Kilowatt? A:—5 (Lamps) multiplied by 50 (Watts per lamp) equals 250 Watts per hour. 250 (Watts) multiplied by 3 (Hours per night) equals 750 Watts per night. 750 (Watts) multiplied by 30 (Nights) equals 22,500 Watts. 22,500 divided by 1000 equals 22½ Kilowatts. 22½ multiplied by 9 equals $2.025.

Q:—If it costs one dollar to burn four 50 Watt lamps for 100 hours, what is the cost per Kilowatt? A:—4 multiplied by 50 (Wattage per lamp) equals 200 Watts per hour. 200 (Watts) multiplied by 100 (Hours) equals 20,000 Watts. 20,000 (Watts) divided by 1000 equals 20 Kilowatts. $1.00 divided by 20 (Kilowatts) equals 5c per Kilowatt.

Q:—If a gas engine driving a 32 Volt, 20 Ampere generator will run five hours on a gollan of kerosene which costs 10 cents per gallon, what is the cost of current per Kilowatt. A:—32 (Volts) multiplied by 20 Amperes) equals 640 Watts output per hour. 640 (Watts) multiplied by 5 (Hours) equals 3200 Watts. 3200 (Watts) divided by 1000 equals 3.2 Kilowatts. 10 (Cents) divided by 3.2 (Kilowatts) equals 3.1c+.

## VOLTAGE DROP

*Ohms* multiplied by Amperes equals Volts drop.

**Volts drop divided by Ohms equals Amperes.**

**Volts drop divided by Amperes equals Ohms.**

**Q:—If a 32 Volt generator is delivering current to a motor that consumes 2 Amperes and the Voltage at the motor terminals is 30 Volts, what is the resistance of the conductors (wires) between the generator and the motor? A:—32 (Volts) less 30 (Volts) equals 2 Volts drop. 2 (Volts drop) divided by 2 (Amperes) equals 1 Ohm resistance.**

Q:—The resistance of a circuit (wires) between a 32 Volt generator and a 32 Volt motor is .2 Ohm and the Voltage at the motor terminals is 30 Volts. What is the rate of flow of current in Amperes? A:—32 (Volts) less 30 (Volts) equals 2 Volts drop. 2 (Volts drop) divided by .2 (Ohm) equals 10 Amperes.

Q:—A 32 Volt generator is delivering current to a motor which is consuming 4 Amperes and the resistance of the conductors between the generator and the motor is .5 Ohm. What is the Voltage drop at the motor terminals? A:—.5 (Ohm) multiplied by 4 (Amperes) equals 2 Volts drop.

Q:—Two Electric fans consuming 2 Amperes each and 4 twenty-five Watts lamps are being operated from a 32 Volt battery. In how many hours will they consume one Kilowatt? A:—2 (Amperes) multiplied by 32 (Volts) equals 64 Watts per hour for each fan. 64 (Watts) multiplied by 2 (Fans) equals 128 Watts per hour consumed by the two fans. 4 multiplied by 25 (Wattage of each lamp) equals 100 Watts per hour consumed by the four lamps. 128 Watts (current consumed by fans each hour) plus 100 Watts (current consumed by lights each hour) equals 228 Watts per hour. 1000 (1000 Watts equals one Kilowatt) divided by 228 (Watts consumed per hour) equals 4.39 hours +.

**Q:—If a 32 Volt generator is generating current at a 20 Ampere rate and a motor, consuming 5 Amperes and four 40 Watt lamps are being operated, at what rate is the battery being charged? A:—4 (Lamps) multiplied by 40 (Watts per lamp) equals 160 Watts per hour consumed by the four lamps. 160 (Watts) divided by 32 (Voltage of the generator) equals 5 Amperes. 5 Amperes (current consumed by the motor) plus 5 Amperes (current being consumed by the lights) equals 10 Amperes being consumed by the motor and lights. 20 Amperes (output of the generator)**

[redacted]

less 10 Amperes (current being consumed) equals 10 Amperes which is the charging rate.

## FORCE, WORK, ENERGY AND POWER

(Extract from previous editions of No. 1 Book)

When a weight is allowed to remain on the table it exerts a force upon the table, but does not do any work; this is simply a force being exerted, but not moving through any distance. Suppose now we allow the weight to fall off the table; it may fall quickly as in the case where we simply allow it to fall unhindered, or it may fall slowly as in the case of a clock weight, but the point we wish to make is that in both cases, work is done by the weight in falling, and the amount of work done is equal in both cases.

Also, if we wish to raise the weight again to its former position, we must perform a similar amount of work on the weight. This means in other words, that when a weight is raised through any distance, a certain amount of work must be done. The amount depends on the weight moved, and the distance through which we raise it. Also, when we allow a weight to fall, it will deliver a quantity of work. Putting this in a different way, we say that when we raise a weight we store up energy and when we allow the weight to fall it will give back the energy that was stored up.

The proposition of cranking an engine is simply a case of energy. If we crank by hand then we supply energy. If we crank by means of a coiled spring, then energy must be used to coil the spring. If we crank by compressed air, then energy must be used to compress the air, and if we crank by electricity, then we find that it also requires energy before we can generate the current with which we charge our Storage Battery.

It might be interesting to note here that when we have an electric cranking system on a motor car, it is actually the gasoline, or part of it, that cranks the engine, because the gasoline is used to drive the engine; then some of the power developed in the engine is used up in driving the generator, and gnerating electricity. By means of the electricity we store up energy in the Storage Battery and this energy is used when we allow current to flow through the electric motor for the purpose of cranking.

We are all familiar with the name "Horse Power," but if asked to say what it is, might have some difficulty. Suppose

we now figure out from what the name "Horse Power" was derived. We must go back to certain principles in this case. Having just spoken of the effect of a weight moving through a certain distance, we will say that the pound is the unit of weight and the foot is the unit of distance. If a weight of one pound is raised through a distance of one foot, the amount of work done is called a foot pound. If the same weight is raised through a distance of two feet, two foot pounds of work has been done. Weight in pounds multiplied by distance raised in feet gives the number of foot pounds of work done. This explains the meaning of the word work.

The word power means the rate of doing work. If a weight of one pound is raised through a distance of one foot in one second, work has been done at the rate of one foot pound per second. If a weight of one pound is raised one foot in two seconds, then the rate of doing work is only one-half as fast as in the former case. This will be easily understood in the following example: Going 100 miles in 10 hours is traveling at the rate of 10 miles per hour. Going 100 miles in 20 hours is traveling at the rate of 5 miles per hour. If twice the time is taken to travel this distance, work is being performed at only half the rate.

When a weight of one pound is raised through a distance of 550 feet in one second the power consumed in raising this weight this distance in one second is equivalent to one "Horse Power." It is usually stated that a "Horse Power" is equivalent to 550 foot pounds per second. If 10 pounds is lifted 55 feet in one second, or 275 pounds is lifted 2 feet in one second, it has required one horse power to do this work. Any two numbers, one of them in pounds and the other in feet, when multiplied together so as to give 550 Foot Pounds per second, is equivalent to one Horse Power.

The important thing to notice in connection with power is, that we must take the time into consideration. The faster we wish to perform a certain quantity of work, or a certain number of Foot Pounds, the more power it requires to do it. An example will make this clear.

How many Horse Power must we have in order to raise an elevator, whose total weight when loaded, is 3,000 pounds? We can not answer this question until we have some other data. We must know, not only the weight of the elevator, but the distance through which we must raise it, and also

the time allowed for it to travel through this distance. Suppose, then, the distance is 220 feet, and we wish to raise the elevator in 2 minutes. We can now proceed to solve the problem. We have 3,000 pounds multiplied by 220 feet, gives us 660,000 Foot Pounds. The time is 2 minutes, but note we must first of all change this into seconds; that will be 2 times 60 or 120 seconds, and if we divide 660,000 by 120, it will give us the number of Foot Pounds of work that we must perform in one second. But 550 Pounds in one second, equals one Horse Power. So if we divide our last result by 550, we get the number of Horse Power necessary to raise the elevator. This example is worked out in full to show the results stated above.

220 feet multiplied by 3,000 equals 660,000 foot pounds.

660,000 foot pounds divided by 120 equals 5,500 foot pounds per second.

5,500 divided by 550 equals 10 H. P.

## TRANSMISSION OF POWER

(Extract from previous editions of No. 1 Book)

Electricity is a means of transmitting power, and may be compared with other ways of transmitting power, such as a system employing belts and pulleys, or a water system where water under pressure is used. In the latter case a pump is used to produce the required pressure on the water which is conveyed by suitable pipes to the water motor or motors where the power transmitted by the water is converted into work. Valves are used to regulate the amount of water flowing in the pipes, or to shut it off entirely. In the case of electricity a generator is used to produce the required voltage in the electricity, which is conducted by suitable wires to the electric motor or motors where the power transmitted by the electricity is converted into work. Switches are used to open and close the circuits, and Rheostats are used to regulate the amount of current flowing through the wires. To figure the amount of power transmitted by electricity we take the voltage or pressure multiplied by amperes or rate of motion, because we have already said that the ampere is the unit of rate or flow of electric current. This gives us a new unit called a watt which is power transmitted electrically.

Volts times amperes equals watts.

We might call it a "volt ampere," just the same as we

**talk about a "foot pound" per second when considering mechanical power. When we want to figure on larger quantities of power, we say 1,000 watts equals 1 Kilowatt or K. W. Now there is a connection between mechanical power and electrical power, and we say that 746 watts equals one Horse Power, or a kilowatt equals about one and one-third Horse Power. In this way we can easily change kilowatts to horse power or horse power to kilowatts. Horse Power is usually written H. P.**

**The power transmitted by electricity is easily calculated. Measure the voltage with a voltmeter, and the amperage with an ammeter, then volts times amperes equals watts and 1,000 watts equals 1 Kilowatt or K. W. The number of Horse Power or H. P. is found by dividing the number of watts by 746, because 746 watts equals 1 H. P. If the voltage was 6 and the amperage 100, this would equal 6 times 100 or 600 watts. Stated in H. P., this would be 600 divided by 746, or 8 tenths of a Horse Power.**

## WATER ANALOGY

The following analogy, or comparisan between the action of an electric system and that of a water system will explain some of the terms used. The pump (generator) forces the water (current) through the pipes (wires) at a certain number of pounds (volts) pressure as indicated by a pressure gauge (volt meter), to overcome the friction resistance) of the pipes (wires) in order that the water (current) may flow at the rate of so many gallons amperes) per hour as indicated by a water meter (ammeter). If the pipes (wires) are too large the cost will be too great. If they are too small the loss will be too great. The pipes (wires) might be so small that the friction (resistance) would absorb a very large portion of the power of the pump (generator) leaving little remaining for useful effect. The pipes (wires) require valves (switches) to regulate and direct the flow of water (current) without leak (drop) and safety relief valves (fuses) must be provided to prevent damage from over-pressure over-voltage).

## ELECTRIC CRANKING SYSTEM.

There should be no trouble in understanding what a cranking system is. We have only two units which are a storage battery, where we store energy, and a motor which uses this energy to crank the engine. This energy must be

replaced in the storage battery. To replace the energy taken from the storage battery, we must employ a generator. It will be necessary to use other pieces of apparatus to control and direct current, whether used for cranking or for re-charging the storage battery. In this case note carefully, that when charging a storage battery, we are simply storing up energy in it, and when we take current from a storage battery, whether we use it for cranking, lighting, ignition or for any purpose, we are using up some of the energy stored in the battery. This point will be taken up when we come to consider the storage battery itself.

## MAGNETISM

If an insulated wire is wound around a bar of iron or steel and a current of electricity is passed through the wire, something strange occurs. The bar will atract pieces of iron or steel as long as current is passing through the wire. This power to attract pieces of iron or steel is called magnetism. If the bar of iron or steel is very soft it will loose its magnetism as soon as the current ceases to flow. If the bar is of hardened steel it will retain its magnetism after the current ceases to flow and will be known as a permonent magnet.

A permanent magnet when suspended in the center either by a pivot or a string will turn so that one end will point to the north and the other end will point to the south. The end that points to the norh is called the north pole and the end that points to the south is called the south pole. If another permanent magnet is brought close to a permanent magnet that is suspended the following interesting things will be observed: When the north pole of the magnet is brought close to the north pole of the suspended one, the suspended one will immediately rotate away. If the north pole of the magnet is brought close to the south pole of the suspended one the suspended one will immediately rotate toward it.

The simple laws of magnetism are: A magnet has two poles. One is called the north pole and the other is called the south pole. The north pole points to the north and the south pole points to the south if the magnet is free to turn. Also that like poles repel and unlike poles attract. To show attraction of unlike poles and repulsion of like poles, sprinkle iron filings on a paper. Bring two like poles up close to the paper just beneath the iron filings, keeping the poles at least an inch apart. (See Fig. 7). The iron filings will present the

[redacted]

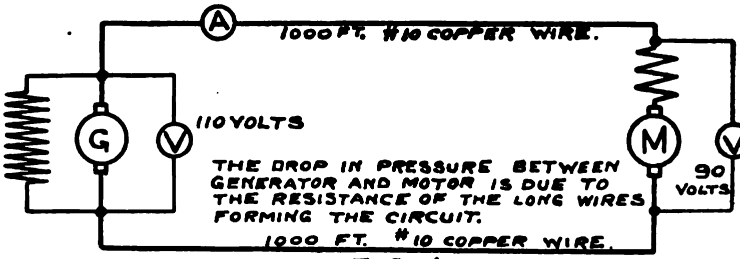



FIG. 1

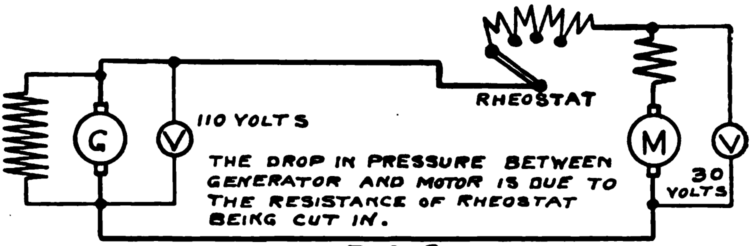



FIG. 2

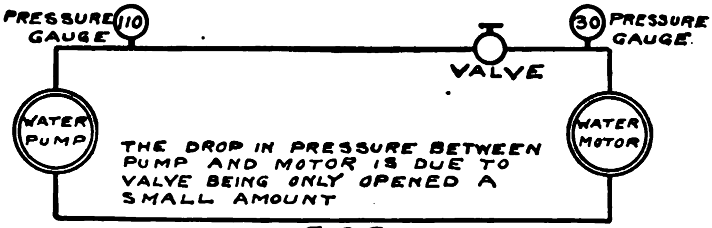



FIG. 3

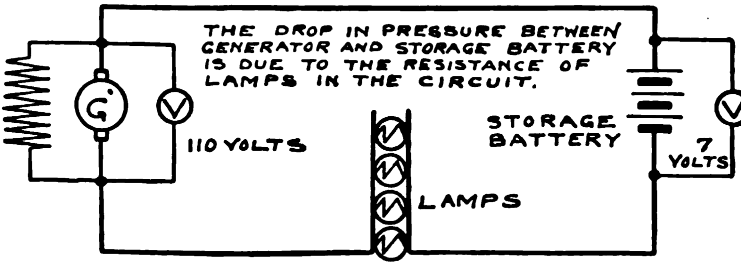
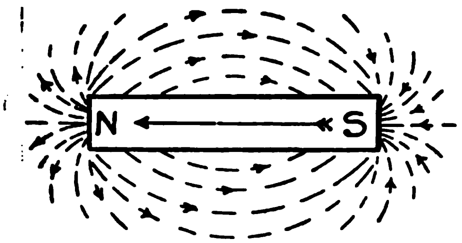
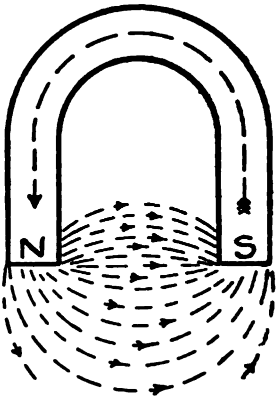



FIG. 4




BAR MAGNET
AND
LINES OF FORCE
FIG. 5




HORSESHOE MAGNET
AND
LINES OF FORCE
FIG. 6

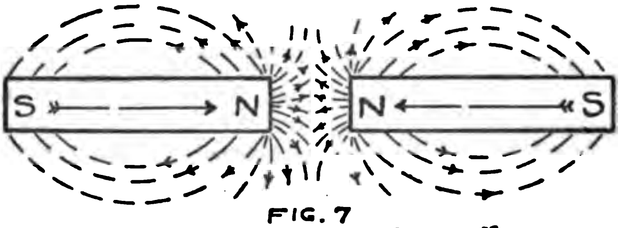



FIG. 7
REPULSION OF TWO "LIKE" POLES

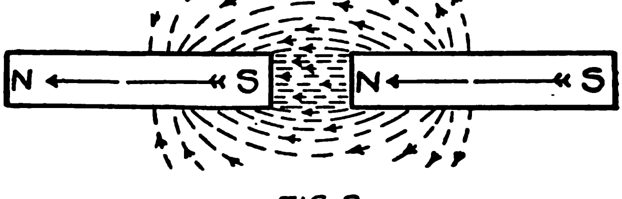



FIG. 8
ATTRACTION OF TWO "UN-LIKE" POLES

appearance of two jets of water being forced against each other. If two unlike poles are placed beneath the paper in the same position as that of the like poles, the iron filings will form in strings or cords between the two unlike poles. (See Fig. 8). The following questions and answers will assist in making the subject of magnetism more clear:

Q:—What is a magnet? A:—A magnet is a piece of iron or steel which possesses the power of attracting other pieces of iron or steel.

Q:—What is this power called? A:—Magnetism.

Q:—What other term is used to describe magnetism? A:—Magnetic flux. And where the flux passes from pole to pole of a magnet through the air or other non-magnetic material it is called the magnetic field.

Q:—Is non-magnetic material an insulator to magnetism? A:—No. It is impossible to insulate from magnetism.

Q:—In which direction does magnetic lines flow? A:—Out side of a magnet from the north to the south pole and in the core of the magnet from the south to the north pole.

Q:—What are the poles of the magnet. A:—the ends of the core of the magnet to and from which the flux passes.

Q:—What is an electro magnet? A:—If a wire is wound around a bar of iron or steel that is soft and a current of electricity is passed through the wire the bar will become magnetized quickly and will remain in this condition as long as the current flows. As soon as the current ceases to flow, it will quickly loose its magnetism. Such an arrangement is called an electro magnet.

Q:—Does it make any difference how the wire is wound around the iron or steel core? A:—Yes. It should be wound continuously in one direction. Then the polarity of this magnet wiil depend upon the direction the current passes through the wire.

Q:—What governs the strength of a magnet? A:—The number of turns in the magnetizing coil, strength of the current flowing and the quality of the path through which the magnetic flux passes.

Q:—How may the polarity of a magnet be determined? A:—Facing the dial of a clock, wind an insulated wire around the hand spinddle in the direction the hands travel and send

a current through the wire in the same way. The end the hands are on will be the south pole and the other the north pole.

Q:—What determines the quality of the core of a magnet? A:—the kind of metal. Annealed wrought iron is best, annealed cast iron next and soft cast iron third.

Q:—Why does a magnet attract other pieces of iron or steel? A:—Because the iron or steel is a better conductor of magnetism than the air and lines of force exert their powers in the direction of shortening their travel. A piece of iron or steel if placed within the range of the flux from a magnet and left free to move will be pulled into that position which gives the lines of force the shortest path through it from the north to the south pole of the magnet.

Q:—What is the name of the piece upon which the magnet exerts its power? A:—The armature. The armature will always be drawn into that position which gives the lines of magnetic force the shortest path from pole to pole through the armature within the range of its movement.

Q:—Is there any limit to the magnetic flux that can be forced through iron or steel? A:—Yes. Beyond certain degrees of magnetization called "working points" the magnetic resistance of iron or steel increases so rapidly that a considerable increase of magnetizing power produces only a small amount of magnetism. Then the magnet's core is said to be nearly saturation. Finally a point is reached when an increase in magnetizing power produces no appreciable increase in magnetism. Then the core is saturated.

It may be said that iron orsteel is made up of molecules or little magnets which, in their original state, are in confused positions. When a surrent of electricity is passed through a wire that surrounds a piece of iron or steel, the molecules or little magnets have a tendency to straighten out parallel with each other. As the quantity of the current increases that passes through the wire the molecules or little magnets continue to straighten out parallel with each other until they are all straightened out end to end. Then an increase in current will not cause the piece of iron or steel known as the core to increase in its power of attraction, because the core is perfectly saturated.

## MOTORS

A motor is constructed in the same way as a generator,

and the term motor does not refer to the way the machine is built, but to the way in which it is used. Any direct current machine may be used as a motor or generator. If a machine is to be used as a generator only, it will be designed to give the best efficiency for that purpose, while its efficiency as a motor might be very low, and the same thing applies to a motor. We have defined a motor as a machine used to convert electrical energy into mechanical energy. This means that we reverse the order of things found in a generator, and instead of revolving the armature by the use of mechanical energy and obtaining electrical energy from the brushes, we introduce electrical energy at the brushes and so cause the armature to revolve. The power thus delivered by the armature can be used in any desired way as for example, when we connect the armature shaft to the crank shaft of an automobile engine for the purpose of cranking. This connection is made by means of gearing.

## GENERATORS

Fig. 8 (Page 20) shows two magnets, placed with the north pole of one toward the south pole of the other, showing lines of force flowing from the North Pole to the South Pole through the air, and we will use a simple diagram of this to illustrate the principles of a generator. Fig 9 shows the two magnets, mounted on a steel frame which also acts as a return path for the magnetism or lines of force. Magnetism flows much more readily through iron or steel than it does through air. By introducing the steel frame, we have cut down considerable resistance to the flow of magnetism by shortening the path through the air.

Now, if we take a loop or coil of insulated wire with the two ends connected together, and revolve this loop or coal between the poles of the magnets, we find that a current of electricity begins to flow, or is said to be generated in, the coil of wire; but remember that we must have magnetism or lines of force flowing from one pole to the other and we also must have a completely closed circuit in the loop or coil of wire, before any current will be generated in it.

Fig 10 shows the coil, placed in such a position, that the lines of force are flowing through the coil. If we now give the coil one-half revolution, we will see that in order to do so, we must cut all the lines of force that were previously flowing through the coil, and the same things happen every half revolution. This would cause the current generated in

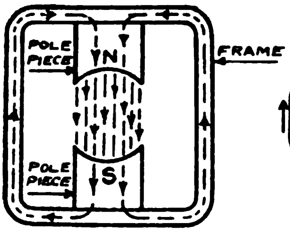



FIG. 9

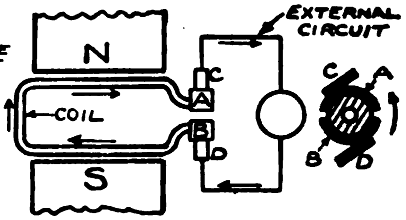



FIG. 11

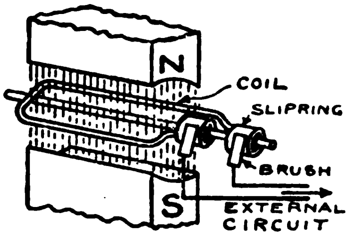



FIG. 10

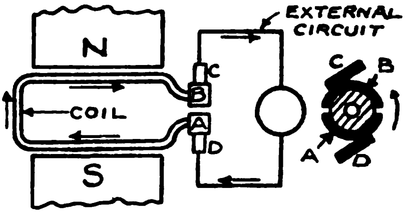



FIG. 12

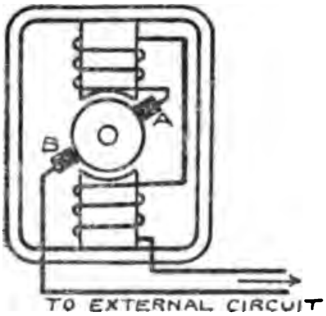



FIG. 13

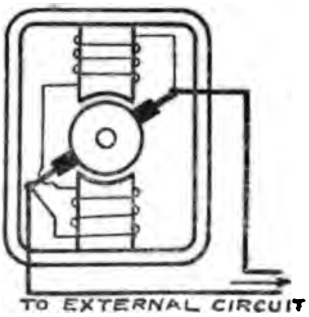



FIG. 16

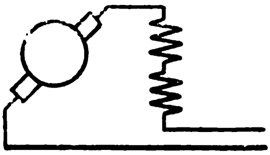


FIG. 14

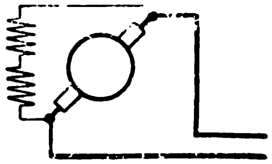


FIG. 17

the coil to reverse its direction of flow every half revolution, which means that we would have an alternating current in the coil. An example of this will be found in the Magneto.

In order to obtain direct current or continuous current, as it is sometimes called; that is current flowing continuously in the same direction and not alternating, we must have some means of preventing the alternate reversal of the flow of the current after it leaves the genrator. This is done by means of the Commutator, which is composed of a number of segments of copper. Fig. 11 shows the single coil, having one end connected to segment "A" of the commutator, and the other end connected to segment "B." Brush "C" is in contact with segment "A" and brush "D" is in contact with segment "B," the circuit through the coil being completed by means of a wire connecting brushes "C" and "D" called the external circuit.

The direction of the flow of current in the coil and in the external circuit is shown by the arrows. Notice that it flows from "B" to "A" in the coil, and from "C" to "D" in the external circuit. When the coil has revolved through half a revolution, segment "A" will be under brush "D," while segment "B" will be under brush "C" as shown in Fig. 12. This means that although the current has reversed its direction in the coil, it is still flowing in the same direction through the external circuit or wire joining "C" and "D."

Notice that current flows from "A" to "B" in the coil during this half revolution, while the direction is the same in the external circuit as in the first half revolution, that is from "C" to "D." In this way we have a flow of current always in the same direction through the external circuit.

An armature consists of a steel shaft upon which are placed a number of iron disks, slotted out to receive a number of coils similar to the one described, and these coils are connected to the segments of the commutator which is also mounted on the same shaft. As each coil in turn, revolves through the magnetic field, current is generated into it, and the brushes are placed in such a position that they collect this current from the various coils and deliver it to the "line," as it is called. This current may be used for charging batteries or for any other purpose where direct current is required.

We will now explain how megnetism is produced in the pole pieces. This can be obtained in two different ways. First, by means of permanent magnets as used on magnetos

where there is no regulation of current. Second, by means of Electro Magnets for the pole pieces, when we wish to regulate the amount of current generated.

Series Wound. Fig 13 shows how the current is taken to megnetize the poles of a Series Wound Machine. It will be noticed that all the current generated in the armature, passes out of brush "A," and from there goes through the upper field coil, as it is called, then through the lower field coil before it passes out to the line, the return circuit being completed through brush "B." Fig. 14 illiustrates how this circuit is shown in a simplified way.

Shunt Wound Machine. This type of generator is so called because only a part of the current flows through the field coils to magnetize the pole pieces, or to "excite the field" as it is usually called. The word shunt really means to switch, or divide the flow of current. In this machine some of the current is switched off the main circuit and goes through the field coils. This machine is shown in Figs. 16 and 17, the latter being a simplified machine.

## THE DELCO-LIGHT SYSTEM

This system is composed of a gas engine, generator and storage battery.

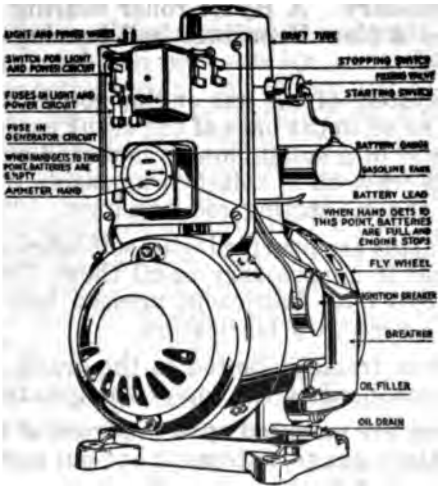
The gas engine is directly connected to a generator, the whole forming a single unit of compact design and of the simplest arrangement.

**The Gas Engine.** The gas engine is of the air-cooled type, the air being expelled through the fly wheel which is made in the shape of a fan. Cold air enters at the top of the cylinder where the heat is greatest, and passes down inside a tube which entirely surrounds the cylinder. This proves to be a very satisfactory arrangement and the air cooling has the advantage of doing away with all danger of freezing in the winter time, as might be the case if water was used to cool the engine.

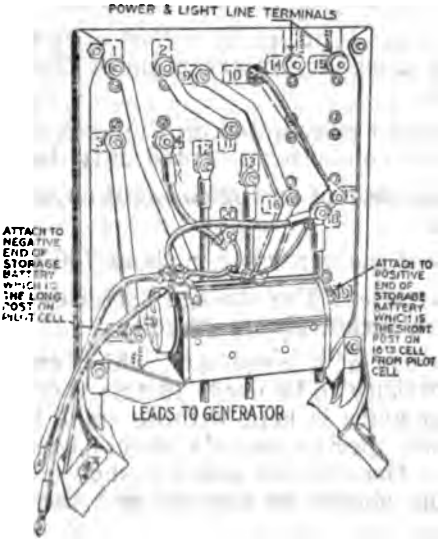
Overhead valves are used, which make them readily accessible for adjustment.

The valves are mounted in the cylinder head, which is removable.

The crank shaft is extended on both sides of the crank case. The generator armature is mounted on one end of this shaft and the fly wheel on the other. In this way, only two




**Delco Light, January 1, 1917**




**Back View of Switchboard January 1,1917**

bearings are necessary. A Hyatt roller bearing is used at the flywheel and a New Departure ball bearing is used at the armature end.

The oiling system of the gas engine consists of a gear, which dips into the oil in the base of the crank case. This gear is driven by means of a small pionion mounted on the crank shaft and in this way, oil is splashed up inside the cylinder walls and on to the connecting rod bearings.

The rocker arms are provided with self-lubricating bearings which makes it unnecessary to oil them. The bearings on the rocker arms have lubricacnt pressed into them, and this provides the necessary lubrication.

The generator frame is bolted to the crank case. The switch board is mounted on the top of the geenrator frame.

The following are mounted upon the front of the switchboard:—The battery gauge, automatic cut-out and the necessary fuses and switches.

The battery gauge registers the current in and out of the batteries.

**Ignition:** The ignition current used for starting up the plant is obtained from the storage batteries. (32 volts.)

The timer-shaft is driven by means of spiral gears, and in this way, the necessary interruption of the ignition current is obtained.

An ignition coil is mounted on the back of the switchboard and has the condenser mounted in its base.

The average speed of the Delco-Light engine is from 900 to 1000 R. P. M.

The output of the generator is about 750 Watts.

**Storage Batteries:** The storage batteries consist of 16 cells connected in series, giving 32 volts.

These cells are of a large size, which enables a large quantity of electricity to be used. In this way the variation in the specific gravity is kept withing small limits. When fully charged the specific gravity should be from 1210 to 1220, and when the specific gravity shows from 1180 to 1190, the engine should be started and the batteries recharged.

Glass jars are used and this makes possible the use of a pilot cell.

The pilot cell has a pocket in one end, in which is placed a while ball which indicates by its position, the condition of the storage batteries. When the ball is at the top, it indicates that the battery is well charged, although it does not necessarily indicate that the battery is completely charged. When the specific gravity of the battery falls to about 1190 the ball falls to the bottom of the pocket. This indicates that it is time to start the engine and recharge the batteries.

The advanages of having the electrolyte vary between small limits, are first, that by not having the specific gravity any higher than 1220, the plates and separators are not subjected to the same injury as would be the case if the gravity was higher. The second advantage is, that by not having the specific gravity fall below about 1190, the batteries will not freeze, until an extremely low temperature is reached.

Another important feature of these batteries is that the plates are very thick. This insures that they will not be easily damaged, and in this way the life of the battery will be prolonged, and its efficiency increased.

What the Delco-Light Plant Does: One of the principal things that the Delco-Light plant does is to provide good lighting at a very cheap rate. The plant will run on gasoline, kerosene, or natural gas, and the cost of producing current for light or power, will, of course, depend upon the price of fuel used. If natural gas is used the cost may be as low as 1½c per kilowatt hour, and if gasoline is used as a fuel, the price will be higher.

Using kerosene as a fuel the plant may be run for approximately 5½ hours to a gallon.

Using gasoline as a fuel the plant may be run for approximately 4½ hours to the gallon.

Among the other advantages of Delco-Light, are the use of small motors up to ½ H. P., which may be used in performing work about the farm, such as usually has to be done by hand.

These motors can be operated very cheaply and there is a great advantage that they can be easily moved from place to place and used wherever required.

## QUESTIONS AND ANSWERS ON MOTORS AND GENERATORS

Q:—What is a motor? A:—A machine used to convert

electric energy into mechanical energy.

Q:—What is a generator? A:—A machine used to convert mechanical energy into electric energy.

Q:—What are the most important parts used in the construction of a motor or generator? A:—Frame of machine, Pole pieces, Pole shoes, Armature, Field coils and brushes.

Q:—What is the material of the frames of the best machines. A:—Drop forged steel.

Q:—Why is this best? A:—Because more lines of force can be provided for the same volume of metal.

Q:—What is a pole piece? A:—The part of the metal frame surrounded by the field coil.

Q:—What is a pole shoe? A:—The metal on the end of the pole piece next to the armature. In many machines it is a part of the pole piece.

Q:—What is an armature? A:—A piece of steel or soft iron, or a collection of such so placed as to be acted upon by either a permanent or electro magnet.

Q:—Where is the armature located? A:—In the center of the machine.

Q:—How can it be distinguished? A:—It is the revolving part.

Q:—Name the parts used in the construction of an armature. A:—Shaft, laminations, commutator, wire and insulating material.

Q:— How is an armature constructed? A:—Laminations with slots cut in the outer edges are assembled on the armature shaft along with the commutator. Into the slots of the Laminations the insulated wire is wound, the ends of the coils of wire being connected to the commutator.

Q:—What is a commutator? A:—Copper bars assembled side by side in a cylindrical form. The bars are insulated from each other with strips of mica. The bars of copper are called segments.

Q:—What is the use of the commutator? A:—It assists in making a flexible connection between the outer circuits and the windings of the armature. It also assists in reversing the direction of flow of current.

Q:—Are currents generated into the armature alternating or direct? A:—Alternating.

Q:—How are they converted into direct current? A:—By the use of the comutator and brushes. The coils of wire on the armature are so connected to the commutator that the current taken off by the brushes is direct current.

Q:—What are the brushes used for? A:—The brushes rest on the commutator and serve to make the connection to the windings of the armature.

Q:—When is current introduced into the armature? A:—When a machine is operated as a motor.

Q:—When is current taken from the windings of an armature? A:—When a machine is operated as a generator.

Q:—What is the composition of brushes? A:—They may be made of carbon, carbon and metal, or metal.

Q:—Why is a flexible connection to the commutator necessary? A:—The commutator is fastened to the armature shaft and revolves with it.

Q:—What is the best way to mount the brushes? A:—On arms.

Q:—What are the objections to a pocket type brush holder? A:—Dirt and gumming of the commutator will cause them to stick up and cause a poor contact between the brushes and the commutator.

Q:— What are the advantages of mounting brushes on arms? A:—Preevnts sticking up and assures uniform pressure of brushes on the commutator.

Q:—How much of the end surface of the brush should make contact with the commutator? A:—The total end surface.

Q:—Why? A:—The more of the end surface in contact with the commutator the less the resistance of contact.

Q:—Give proper method of fitting a brush to a commutator? A:—Use strip of about No. 0 sand cloth the full width of the commutator and insert between brush and commutator with rough side next to brush. Then sand as shown in Figs. 23 and 25. Care must be taken that the sand cloth is not pulled back and forth as shown in Figs. 24 and 26, as this will cut the corners of the brushes away.

Q:—Should emery cloth be used? A:—No. Emery is a conductor and should be kept away from a machine.

Q:—Should a commutator be lubricated. A:—No. It will cause dirt to accumulate and prevent good brush contact.

Q:—How are the commutator bars (segments) insulated from each other. A:—With strips of mica.

Q:—Do the mica insulations wear as fast as the copper bars? A:—That depends upon the kind of brushes used.

Q:—What kind of brushes are most commonly used? A:—Carbon brushes on generators and metite or metal brushes on motors.

Q:—With what kind of brushes does the mica wear as fast as the copper? A:—Where the metal or metite brushes are used.

Q:—Where carbon brushes are used what should be done to the micas? A:—They should be kept groved below the surface of the copper.

Q:—If in the wear of the commutator the micas become high, what will result? A:—Brush will not make good contact with the commutator, causing arcing.

Q:—Can the micas be grooved out when the armature is in a machine. A:—No. The armature must be taken out.

Q:—What should be done first when armature is put in the lathe? A:—Run the tool carriage along to see that it will not strike the armature while commutator is being trued up.

Q:—What should be done then? A:—The surface of the commutator should be trued up.

Q:—How should the groove in the mica be started? A—With a three-cornered file, being careful not to cut away copper. See Fig 18.

Q:—How should the groove be finished? A:—with a piece of hacksaw blade the same thickness as that of the mica. See Fig 19.

Q:—What should be done if the hacksaw blade is too thick? A:—It should be ground to the proper thickness.

Q:—How deep should the groove be cut? A:—About one thirty-second of an inch.

Q:—What will result if edges of micas are not cut away clean? A:—If the brushes strike them they will be broken off, and sparting will occur. See Figs 20 and 21.

Q.—What should be done to a commutator after groov-

ing out the micas? A:—It should be sanded and polished. Use medium fine cloth. Speed up the armature and sand as shown in Fig 22, pulling the ends back and forth. Then use cheese cloth and polish.

Q:—How can a commutator be sanded in a machine? A:—Some as out of machine, care being taken that the brushes do not rest on the sand cloth.

Q:—What will result if a piece of sand cloth is held on the commutator under the finger's pressure? A:—This will groove out the copper and cause uneven surface. Then brushes will fit poorly.

Q:—After grooving out the micas do the brushes require any attention? A:—Yes. They should be fitted to the commutator.

Q:—What can be used to loosen an accumulation on the commutator? A:—Coal oil (Kerosene).

Q:—What should be done before applying the coal oil? A:—Brushes must be lifted and not come in contact with the coal oil.

Q:—How should the coal oil be applied? A:—With a cloth, being careful to apply only to the commutator.

Q:—How long should the coal oil be left on the commutator? A:—About five or ten minutes.

Q:—What should be used to wipe a commutator? A:—Cheese cloth.

Q:—Why cheese cloth? A:—Because it is nearly free of lint.

Q:—What effect will lint have? A:—It will be drawn under the brushes or adhere to the segments and cause arcing at the brush contact.

Q:—Why not use gasoline when cleaning a commutator? A:—It may get into the winding and evaporate for a long time. When the machine is operated it might be ignited.

Q:—How often should the bearings be lubricated? A:—When oiling other parts of the car.

Q:—What are the circuits of the motor or generator called? A:—Internal circuits.

Q:—What are external circuits? A:—This term is applied as a rule to the wiring between the different pieces

of apparatus.

Q:—In testing a machine is a buzzer and dry cells good? A:—In some cases it is all right. If used in testing shunt field circuits the resistance may be so high that the buzzer will not operate. It is always best to use the 110 volt lighting circuit and connect lamp in series with the test wires.

Q:—What is meant by shunt field? A:—Field windings connected across the brushes of the machine. See Figs. 16 and 17.

Q:—What is meant by series field? A:—Field windings connected in series with the armature. See Figs 13 and 14.

Q:—What care should the owner of a car give a motor or generator? A:—Keep the bearings lubricated and commutator clean.

## THE STORAGE BATTERY

**Note: The gravity readings, proportions of sulphuric acid and water used in making electrolyte, height of solution in cells, charging rates and material of battery jars in the following information pertains to the storage battery as applied to automobile electric systems other information pertains to all lead plate batteries.**

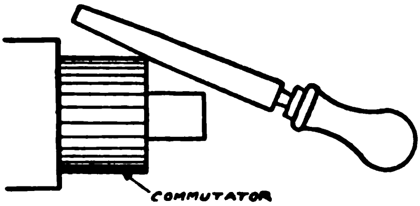
A storage battery is composed of rubber jars, lead plates, plate separators and electrolyte.

The plates are made by first casting lead into grids. Then a composition made of lead oxides is pasted into these grids. This composition is better known as active material. This active material sets hard like cement when dried and remains so during the life of a battery. After the active material is compressed into the gride they go through an electro chemical process that converts that of the positive plates into brown peroxide of lead and that of the negative plates into spongy metallic lead.

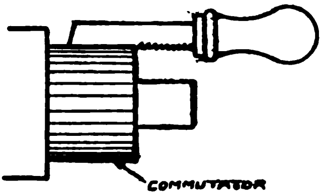
The jars are made of rubber to prevent the acid from affecting them. There are always three cells in a 6 volt storare battery. These jars are so constructed that the plates rest on a stool about one inch from the bottom of the jar. This space is for the sediment that will accumulate as the battery wears.

The plate separators are made of either wood or hard rubber. They are used to separate the plates of different polaritis from each other. Also to prevent foreign sub-

# COMMUTATOR AND BRUSHES



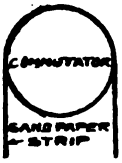

STARTING GROOVE IN MICA WITH 3-CORNERED FILE.
FIG.- 18.



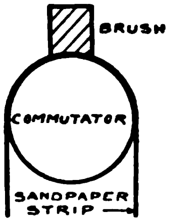

SLOTTING MICA WITH PIECE OF HACKSAW BLADE
FIG.- 19.


RIGHT WAY
MICA MUST BE CUT AWAY CLEAN BETWEEN SEGMENTS.
SLOTTING MICA
FIG.- 20.

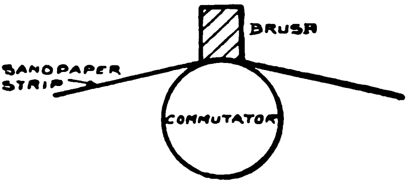

WRONG WAY
MICA MUST NOT BE LEFT WITH A THIN EDGE NEXT TO SEGMENTS
SLOTTING MICA
FIG.- 21



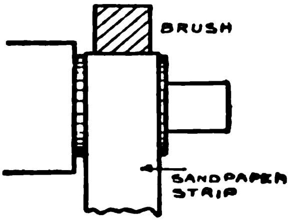

SANDING COMMUTATOR
FIG.-22



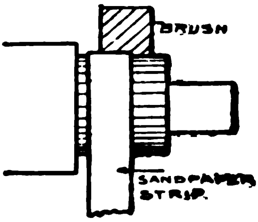

RIGHT WAY
FIG.- 23




WRONG WAY
FIG.- 24




RIGHT WAY
FIG.-25




WRONG WAY
FIG.- 26

SANDING BRUSHES

stances from causing short circuits.

The electrolyte or exciting fluid is made by mixing chemically pure sulphuric acid with distilled water in definite proportions.

The gravity of water is 1.000 and that of acid is 1.840. Mixing of 2 parts of acid with 5 parts of water should make electrolyte of about 1.300 gravity.

To make electrolyte, first secure an earthen vessel of a desired size. Pour the distilled water into the vessel and then add the acid. Be sure to add the acid slowly and stir all the time it is being added. We would suggest the following: If 7 gallons of solution is to be made, first pour 5 gallons of distilled water into the vessel and then add the acid as follows until two gallons have been added; pour one quart of the acid into the water slowly and stir while so doing; let set 15 minutes and then add another quart in the same way. Continue this operation until the two gallons of acid have been added. Always be sure to use only distilled water and chemically pure surphuric acid. When the above solution is cooled the gravity should be about 1.300. If it is above this a little water should be added, and if below 1.300, a little acid should beadded. Be sure that the solution is in a cooled condition when testing the gravity.

Any water used in a battery should be distilled. Water contains minerals, salts, etc., which are injurious to the active materials. Distilled water for a storage battery should be kept in bottles and corked up tight.

The true gravity of the solution in a storage battery can only be ascertained by charging the battery until the gravity of the solution has ceased to rise for a period of at least two hours. As a battery is being charged the acid is forced out of the plates and mixes with the water and the gravity of the solution increases. As a battery is being discharged the acid leaves the water and goes into the plates and the gravity of the solution decreases.

When the battery is in a discharged condition the solution will test about 1.150. It should not be used when the gravity is this low, but should be given a charge at once. If the gravity of the solution in a battery is low, add only distilled water until the plates are covered from 3/8" to 1/2" and then give it a charge. Charge until the gravity of the solution ceases to rise for a period of at least two hours. At this time the gravity of the solution should test between 1.275

and 1.300.

The rate a storage battery should be charged from an outside source depends entirely upon the size of the battery and state of charge. If the rated capacity of a battery is 80 ampere hours it should be charged as follows: When the gravity of the solution is below 1.150 or over 1.250, it should be charged at 5% of the rated capacity, or 4 amperes. If the gravity of the solution is between 1.150 and 1.250, it should be charged at 10% of the rated capacity, or 8 amperes. The above are safe rates for any good battery.

Never add pure acid to a battery under any condition. Never add new electrolyte to a battery when it is in a discharged condition. If the solution in a battery tests low it is not a sure indication that the battery needs new electrolyte. The cells should be filled to the proper height with clean, distilled water and then put on charge and charged at the proper rate until the gravity ceases to rise for about two hours. If the gravity fails to rise to 1.275 some of the old solution should be taken out and replaced with new electrolyte of a 1.300 gravity.

While on charge and nearing a fully charged condition a single cell of a storage battery will give off a pressure of 2.5 volts. A 3-cell battery under the same condition will give off a pressure of 7.5 volts. When the charging is ceased the pressure of a single cell will go back to 2.2 volts or 6.6 volts for a 3-cell battery.

The color of the positive plates is brown and that of the negative plates is gray or lead color. When a storage battery is in a fully charged condition there is no electricity in it. Passing a current of electricity through a storage battery causes energy to be stored up in a chemical form which can be converted into an electrical form when desired.

Distilled water is made by boiling water, producing steam, cooling the steam which returns to water. Steam that is cooling must not come in contact with metals other than lead. Never use boiled water in a battery. When water is boiled the part that is pure rises as steam and escapes, and the part that remains is the impurities which are injurious to the active material in the plates of the battery.

Remember, in making electrolyte for a storage battery that 2 and 5 do not make 7. If 2 gallons of acid are mixed with 5 gallons of water it will not make 7 gallons of solution.

In mixing the acid and water heat is produced and some of the water evaporates, causing quantity to diminish.

If there was no evaporation in mixing 2 parts of sulphuric acid with 5 gallons of water the gravity of this mixture would be 1.240. Enough water evaporates while the parts are being mixed to cause the gravity of the solution to be about 1.300 in a cooled condition. When making electrolyte be sure to pour the acid into the water slowly. It is very dangerous to pour the water into the acid.

If the gravity of the solution in a battery tests 1.300 it is an indication that the battery is fully charged. If some one has added electrolyte instead of water to replace evaporation the 1.300 test will be misleading. To be sure of the true gravity keep the battery on charge until the gravity has ceased to rise for two hours. Never let the plates remain exposed to the air for any length of time.

Distilled water should be added to a battery in use at least twice a month. In cold weather never add water to a battery and let the battery set in a cold place unless it has been given a charge after the water was added. Water is lighter than electrolyte and will remain on top and freeze if not mixed with the electrolyte. The terminals of a storage battery should be kept tight and free from corrosion.

If the terminals of a storage battery show signs of corrosion, the corrosion should be removed at once. Take all bolts, nuts, washers and straps off that can be removed readily and clean them with a strong solution of cooking soda and water. Put all parts taken off the battery into soda solution and set aside for half an hour. Then use a short, stiff brush and remove all signs of corrosion. Also clean terminal posts of the battery, being careful not to let the soda solution get into the battery. Wipe all parts dry and give them a good coat of vasoline. After these parts are assembled another coat of vasoline should be given them. If termintls are kept coated with vasoline, corrosion will not occur.

Use a filling syringe when adding water to a battery. Be sure that the top of the battery is dry and free from foreign substance as such will cause short circuits between the terminals of the cells. A fully charged battery testing about 1.300 will freeze at about 90 degrees below zero, and when discharged down to 1.150 it will freeze at about 10 degrees above zero.

Keep the battery and its compartment dry in outer appearance. The wearing of a battery causes sediment to accumulate in the bottom of the cells an must be removed. If sediment is high enough to short circuit across the lower ends of the plates it will cause the battery to overheat, gas excessively, gravity will rise slowly, and when the current is cut off for charging, the voltage of each cell will drop below 2.2 volts per cell and continue to drop. The gravity of the solution will continue to drop, and in a short time the battery will be discharged whether used or not.

To remove sediment from a battery, fill each cell with water to the proper height and place on charge. Charge until gravity in all cells ceases to rise for two hours. Remove plates, set plates in earthen vessel and cover with water. Clean sediment out of cells and wipe them dry. Fill cells about 1/4 full of new electrolyte. Then set the plates into the cells, one set at a time, and immediately cover with new electrolyte. Be careful not to expose to air long. Discharge plates back to a point where the gravity of the solution tests 1200. Then charge until gravity in all cells ceases to rise for two hours.

## VOLTAGE TESTS.

Voltage tests of storage batteries can be made to show the condition of batteries very accurately, provided they are made in the proper way.

Voltage tests with the battery idle may be very misleading. A storage battery may be three-fourths discharged and while idle, show a voltage almost equal to that of a fully charged battery. The voltage of a battery in this condition will drop as soon as current is taken from it. The greater the rate at which you attempt to take current from the battery, the greater the drop in voltage. If a few lamps are turned on the voltage drop may be comparatively small, but if an attempt is made to crank the engine, just as soon as the circuit is completed by closing the starting switch, the voltage drop will be excessive.

Remember this:—A storage battery may be almost discharged and while idle show a voltage of two volts per cell, six volts for a three-cell battery or 32 volts for a 16 cell battery. If an attempt is made to crank the engine, the voltage of this battery may drop as low as 4 volts or less for a 3 cell battery or 20 volts or less for a 16 cell battery, this being due to the attempted high rate of discharge.

## QUESTIONS AND ANSWERS ON THE STORAGE BATTERY AS USED IN CONNECTION WITH AUTOMOBILE ELECTRIC SYSTEMS AND DELCO LIGHT FARM LIGHTING SYSTEMS.

Q:—What is a storage battery composed of? A:—Rubber or glass jars, lead plates, plate separators and electrolyte.

Q:—How are cells in a storage battery connected? A:—In Series.

Q:—What is the voltage of a single cell when fully charged? A:—2.2 volts.

Q:—How high will the voltage of a single cell of battery rise while on charge? A:—2.5 volts.

Q:—Are the terminals of a battery marked? A:—Yes.

Q:—What are the marks? A:—"+" or "Pos." for positive and "—" or "Neg." for negative.

Q:—Name the parts that constitute a single cell. A:—Rubber or glass jar, lead plates, plate separators and electrolyte.

Q:—What is the composition of the active material? A:—The body of the active material is either read lead or litharge.

Q:—How are the plates made? A:—By first casting lead into gride and then compressing active material into them.

Q:—Is the active material soft or hard when dried? A:—Hard like cement.

Q:—What is done after the plates are dried? A:—They are then taken through an electro chemical process which converts the active material of the positive plates into brown peroxide of lead and that of the negative plates into spongy metallic lead.

Q: —What are the colors of the plates. A:—The posititve plate is brown and the negative plate is gray or lead color.

Q: —What are the jars made of? A:—Rubber for automobile batteries and glass for Delco Light batteries.

Q:—Why this difference? A:—For automobile use, *rubber jars are* less liable to break. For Delco Light systems,

glass jars are best because you can see their internal conditions at all times. There is little danger of them breaking as they are stationary.

Q:—Why are they made or rubber or glass? A:—So acids will not injure them.

Q:—What is sediment? A:—Lost active material. This is due to the natural wearing of a storage battery.

Q:—Why is the bottom of a jar called the sediment chamber? A:—Because sediment occumulates there.

Q:—What are the separators made of? A:—Wood and hard rubber.

Q:—What are they for? A:—To separate the plates of different polarities and to prevent short circuits.

Q:—What is the solution in a battery called? A:—Electrolyte.

Q:—What is electrolyte? A:—A mixture of sulphuric acid and water.

Q:—What are the proportions for automobile batteries? A:—Two of acid to five of water.

Q:—What are the proportions for Delco Light batteries? A:—Two of acid to seven of water.

Q:—Are the parts measured by volume or weight? A:—By volume.

Q:—What kind of a vessel should be used in making electrolyte? A:—A glass or earthen vessel.

Q:—When making electrolyte, which part is poured into the other? A:—The acid is poured into the water.

Q:—How fast? A:—The acid should be added slowly.

Q:—Why? A:—To prevent excessive heating of the solution which might cause the mixing vessel to be cracked. Also to prevent excessive evaporation.

Q:—What else should be done while mixing. A:—Stir solution.

Q:—What should be used to stir the mixture? A:—A wooden paddle.

Q:—What is the gravity of water? A:—1.000.

Q:—What is the gravity of chemically pure sulphuric acid? A:—1.840.

Q:—What is sulphuric acid? A:—A mixture composed of sulphur, oxygen and hydrogen in definite proportions.

Q:—Does acid evaporate? A:—No.

Q:—Does water evaporate? A:—Yes.

Q:—What should be used to replace evaporation in a storage battery? A:—Distilled water.

Q:—What kind of water should be used in making electrolyte? A:—Distilled.

Q:—Why not use electrolyte to replace evaporation in a storage battery? A:—Because no acid has been lost. Only water was lost.

Q:—Can rain water be used? A:—Yes. If it is clean and has not come in contact with metals or other foreign substances which are injurious to the active materials in the plates of the battery.

Q:—Is boiled water good to use in replacing evaporation? A:—No. Boiling of water only condenses the impurities and the steam escapes.

Q:— How is distilled water made? A:—By boiling water, catching the steam that arises and cooling it. The steam when cooled must not come in contact with other than lead or glass.

Q:—How should distilled water be kept? A:—In glass bottled corked tight.

Q:—When should acid be added to a battery? A:—Never add pure acid.

Q:—When should electrolyte be added? A:—If a battery is put on charge and charged for a period of two hours after the gravity of the electrolyte ceases to rise and the gravity is too low.

Q:—Between what points should the gravity rise when fully charged? A:—1.275 and 1.300 for an automobile battery and 1.215 to 1.220 for Delco Light.

Q:—How do we know when a battery is fully charged? A:—By the gravity. When gravity ceases to rise for a period of two hours.

Q:—What should be done if gravity is too low at this time? A:—Remove a little of the solution in the battery *with the hydrometer* syringe and replace it with electrolyte.

Q:—What should be done if the gravity is too high at this time? A:—Remove a little of the solution and add only distilled water.

Q:—How much solution should be taken out of the battery in either case? A:—This depends entirely upon the lowness or highness of the gravity. It is generally best to take a little out at a time until the gravity is of the proper density when the battery is fully charged.

Q:—What would cause the gravity to be too high? A:—New electrolyte had been added to replace evaporation as a rule.

Q:—How is a storage battery charged? A:—By causing a current of electricity to flow through it.

Q:—Do we store up electricity in a battery? A:—No.

Q:—What is done? A:—The flow of current through a storage battery causes energy to be stored up in a chemical form which can be converted into an electrical form.

Q:—How fast should a battery be charged from an outside source? A:—That depends entirely upon the size of the battery and state of charge.

Q:—What would be a safe rate for automobile batteries? A:—As an example, say we have an 80-ampere hour battery. If the gravity of the solution in the battery is below 1.150 or over 1.250 charge at 5% of the rated (80 ampere hour) capacity which is 4 amperes. If the gravity is between 1.150 and 1.250 charge at 10% of the rated capacity, which would be 8 amperes.

Q:—Why this difference in the charging rate for automobile batteries? A:—When a battery is real low a high charging rate may cause buckling of the plates, and when nearly charged, too high a rate may cause loss of the active materials.

Q:—How often should water be added to a battery? A:—At sufficient intervals that the plates are never exposed to the air.

Q:—How much time between these intervals? A:—That all depends upon temperatures and treatment of the battery.

Q:—What would be a safe time? A:—Ordinarily every two weeks when the battery is in use. In summer time it may be necessary to add a little water between times.

Q:—How much water should be added? A:—Enough that the plates are covered about three-eighths to one-half inch for automobile batteries. Keep solution up to line marked on Delco Light batteries.

Q:—How should water be added? A:—With a filling syringe.

Q:—Why? A:—To prevent spilling of water over the tops of the cells.

Q:—What effect will water have on the tops of the cells? A:—It will cause foreign substances to gather and cause short circuits between the terminals of the cells.

Q:—When should water be added to a batter in winter time? A:—Just before it is to receive a charge.

Q:—Why not any time if the solution is low? A:—Because water is lighter than the electrolyte and it may lay on top of the plates and freeze.

Q:—What does charging do to the water added? A:—It causes it to become mixed with the electrolyte.

Q:—What causes the gravity of a battery to change? A:—Either charge or discharge.

Q:—Why when on charge? A:—When a battery is being charged the acid is forced out of the plates and mixes with the solution and the gravity rises.

Q:—Why when being discharged? A:—When a battery is being discharged the acid is leaving the water and is going into the plates and the gravity drops.

Q:—What is the gravity of a battery in practically a discharged conditon? A:—About 1.150 for an automobile battery and about 1.170 for a Delco Light battery.

Q:—Will a battery freeze? A:—Yes.

Q:—At what temperature? A:—This all depends upon the state of charge.

Q:—At what temperature will an automobile battery freeze when fully charged and gravity is near 1.300? A:—At about 90 degrees below zero.

Q:—When an automobile battery is discharged down to a gravity of about 1.150? A:—At about 10 degrees above zero.

Q:—When should gravity tests be made? A:—When

the battery is being charged or discharged.

Q:—What is wrong if the voltage of a battery falls rapidly when charging is stopped and continues to fall until below 2 volts per cell? A:—A short circuit between plates. Sediment may be causng a short at lower end of plates.

Q:—Is the voltage a sure indication of state of charge? A:—Yes, if tests are made in the proper way.

Q:—How should tests be made to detect a bad cell? A:—While the cranking system is engaged test each individual cell of the battery with a voltmeter. If one cell is bad it will show a decided lower voltage than the rest. This test should be made only when the battery is being discharged at a very high rate.

Q:—What kind of a hydrometer is best to use? A:—Type S-I, made by the Electric Storage Battery Co., of Philadelphia, Pa.

Q:—Are all hydrometers good? A:—No. Many makes are no good. They vary as much as 20% in their readings.

Q:—Can a battery be tested with an ammeter? A:—No.

Q:—Why not? A:—Because connecting an ammeter across the terminals of a storage battery short circuits it.

Q:—What effect will acid fumes that arise while battery is being charged have on the terminals? A:—It will cause them to corrode.

Q:—How can you tell when terminals are corroded? A:—By taking them apart. A greenish deposit will be noted.

Q:—What effect will corrosion have on the terminals? A:—It causes the resistance to increase between the battery terminals and the wires that connect to them.

Q:—What effect will this have on the operation of the system? A:—Battery will be slow to charge. Cranking will be poor on account of the increased resistance to the flow of heavy current for cranking.

Q:—Why should all battery compartments be ventilated? A:—That the acid fumes may escape.

Q:—What can be used to loosen the corrision? A:—A solution of cooking soda and water.

Q:—How much of each? A:—About 6 tablespoons of cooking soda to one-half pint of water.

Q:—What should be done first when removing corrosion? A:—Take off all of the nuts, washers, bolts of connectors possible and put them in the soda solution.

Q:—How long should they remain in this solution? A:—About half an hour.

Q:—Does this remove the corrosion? A:—No. It only loosens the corrosion.

Q:—Then how should it be removed? A:—With a short, stiff brush. In some cases it will be necessary to scrape the terminals to remove it.

Q:—What should be done next? A:—These parts should be dried and coated with vaseline.

Q:—How are the terminal posts of the battery cleaned? A:—First put waste at the base of the post to prevent the solution from getting into the cells, then apply the soda solution and scrape or brush these parts until all signs of corrosion are removed.

Q:—What should be done then to these posts or terminals? A:—They should be dried and coated with vaseline.

Q:—After the parts are assembled what should be done? A:—A good coat of vaseline should be applied to all the connections.

Q:—How often should vaseline be applied in general practice? A:—Two or three times a year.

Q:—What does vaseline do to the terminal parts of a battery? A:—It prevents the acid from causing corrosion.

Q:—What should be done to the terminals of a new battery? A:—They should be given a good coat of vaseline. Should be inspected first to see that corrosion has not started.

Q:—What will result if foreign substances accumulate on top of the battery? A:—They will cause short circuits between the terminals of each cell.

Q:—How should they be removed? A:—By the use of a little of the soda solution and a cloth. Be careful not to let the solution get into the battery.

Q:—What will cause excessive gassing or overheating of an automobile battery? A:—Overcharging, charging too fast or while charging sediment is shorting across the lower ends of the plates.

Q:—What are indications that battery plates are short circuited? A:—Overheating while charging, excessive gassing, slow drop of voltage. Battery will slowly discharge and gravity reading will keep falling.

Q:—How would be a good way to test this? A:—Take gravity reading in the evening before charging is stopped. Then take reading next morning after charge is again started. A decided drop of the gravcity will indicate short circuits. Have battery disconnected over night.

Q:—If sediment is high, what should be done? A:—Communicate with the maker of the battery. If you have had sufficient experience in battery work you may remove the sediment same as the maker of the battery would.

Q:—How would the maker of the battery remove the sediment? A:—First fill each cell with water, charge until gravity ceases to rise for two hours. Stop charge and remove plates. Do not expose plates to the air and let them dry. Set them in a wooden or earthen vessel and cover with water. Clean out sediment; rinse plates and set back in cells. Then cover with new solution to proper height. Never use old solution over.

Q:—What should the gravity of the new solution be for auto and Delco Light batteries? A:—1.300 for auto batteries and 1.220 for Delco Light batteries.

Q:—What should be done to the battery then? A:—Should be slowly discharged through lamps down to 1.200. Then fully charged.

Q:—How would a manufacturer replace a cracked cell in a battery? A:—Disconnect the cracked cell, remove plates from cell and set in enough water to cover the plates. Use wooden or earthen vessel to set plates in. Remove old cell and replace with the new one. Rinse plates, being careful that separators are not out of place. Set plates in the cell and cover them with a weak solution. Put on charge and charge slowly until the gravity ceases to rise for a period of at least two hours. Then remove this solution and replace it with new solution. Then discharge down to the gravity of the solution of the other cells.

Q:—What will cause sulphation of the battery plates? A:—Lack of charge.

Q:—What does this do? A:—It seals the pores of the active materials.

Q:—How may this be removed? A:—By charging.

Q:—At what rate? A:—A very slow rate if the gravity of the solution is very low. Continue to charge for 4 or 5 hours after gravity in all cells ceases to rise.

Q:—What should be done to a battery that is to remain idle for several months? A:—Should be filled with water the proper height and charged until the gravity in all cells ceases to rise for a period of at least two hours. Should be given a refreshing charge at least once every two months while out of service. Should be kept in a dry, cool place and free from dust.

Q:—How much of a refreshing charge should a battery be given each time? A:—Should be charged until gravity is raised near normal. That is, near to that of the gravity reading when the battery was put out of service.

Q:—Is it necessary to take an automobile battery off of the car to charge it? A:—No. It can be charged by the system on the car. If it is charged from an outside source all wires of the electric system on the car that are attached to the battery should be removed before charging lines are connected.

Q:—Does excessive sulphating shorten the life of a battery? A:—Yes. To remove the sulphation it will be necessary to give the battery a heavy overcharge, and this often causes losses of the active material.

Q:—What is meant by "one hundred ampere hour battery?" A:—That if fully charged it will supply current for 100 hours at a discharge rate of one ampere.

Q:—Can this battery be discharged for one hour at a 100 ampere rate? A:—No. At this high rate of discharge efficiency drope quite a lot.

Q:—What kind of current must be used to charge a battery? A:—Direct current.

Q:—Can alternating current be used? A:—If alternating current is to be used it must be converted into direct current.

Q:—How is the best way to rectify this current? A:—By the use of an Edison vibrating rectifier.

Q:—How may the polarity of the charging wires be found? A:—Fill a glass with water, add some salt and stir

well. Then dip the ends of the charging wires into this solution, keeping them an inch apart. Bubbles will rise from the negative wire.

Q:—How should wires be connected to the battery? A:—Positive charging wire to positive of battery and negative charging wire to negative of battery.

Q:—How can we tell the difference between direct and alternating current? A:—When ends of wires are dipped into the salt water bubbles will rise only from one wire if direct current. From both wires if alternating current.

Q:—What is the care a user should give a battery? A:—Keep top of cells dry and free of foreign substances. Keep charged. Keep plates covered by adding distilled water at frequent intervals and note that terminals do not corrode.

## SOLDERING

Very few mechanics or repairmen working on motor cars or electric devices as applied to motor cars realize the importance of soldering all joints or splices when they are made. If a piece of wire is attached to another or to a terminal and taped up without being soldered, the connection will be of a very low resistance at the time, but corrision of the parts will soon take place and offer added resistance to the circuit. This will cause the system to work bad, and, as a rule, the trouble will be hard for the average man to locate. All connections should be soldered when they are made. In soldering wires to terminal clips care should be exercised that the solder does not flow over the portion of the clip that goes under a terminal. When soldering a wire to a clip or making a soldered connection, the tinned side of the iron should be held close to the point where the solder is to unite the two parts. The iron must be held still that all the heat may be transmitted to one point so the solder will flow freely. After soldering always test these parts to see that a good joint is made.

Another thing of great importance is the solution used in soldering. The following solutions are used: Soldering acid (cut muriatic acid), soldering salts, soldering paste, rosin, rosin dissolved in grain alcohol and a solution known as ruby fluid.

To make soldering acid, dissolve zinc into muriatic acid until the acid becomes so weak that it will not dissolve any

more of the zinc. This solution may be used with very good results on large work, but should never be used around insulated wire with a cloth covering. If this solution is used, as soon as the work is done the parts soldered should be washed with a strong solution of cooking soda and water that all of the remaining acid is removed. This acid is a conductor of electricity, and if left on the parts where soldering is done, it will cause light grounds or short circuits, which are very hard to find. Soldering salts and pastes often cause the same trouble, as they are composed of substances as a rule that are high resistance conductors.

Plain rosin or rosin dissolved in grain alcohol is an excellent solution too use. When this is used the parts to be soldered must be cleaned thoroughly. To make this solution, dissolve rosin and grain alcohol into a solution like a thin syrup. If this solution becomes too thick at any time add more grain alcohol. Be sure to keep the container closed when not in use.

Ruby fluid is made by the Ruby Chemical Company of Columbus, Ohio, and is used by many electrical manufacturers in their work. This solution does not act as a conductor, and can be used at all times with safety.

The size and shape of a soldering iron depends entirely upon the class of work to be done| When doing small work use about one-half pound iron with a medium sharp point. Never tin but one side of the iron and then the flow of solder can be controlled at all times. If the work is large, it is best to use an iron from one to two pounds in weight. The point of the iron should be blunt. Remember that you are trying to solder and not scrub, so hold the iron still when soldering. Where an electric iron is used almost continually, it is best to make up a block with switch attached. Then connect a 32-candle power lamp in series with the iron. Then connect the switch so when closed it will short circuit the lamp and let the required amount of current flow into the iron. When not soldering snap the switch off, which will let the light burn. This will reduce the amount of current that will flow through the iron. Then there will be a saving of current, the iron will last much longer, point will remain tinned longer and the iron kept warm enough that when wanted again it will only require a few seconds until it will be hot enough. When tinning an iron the parts to be tinned should be cleaned and hammered first, then tinned. This will cause the tin to remain longer. Use a salammoniac solution to dip

iron in when tinning.

## WIRE SIZES AND DROP

A conductor offers a resistance to the flow of current, and when current flows through the conductor a certain amount of pressure is lost in overcoming this resistance. The greater the distance current flows through a conductor the greater the loss of pressure. This is known as volts drop. See Figs. 1, 2, 3 and 4.

If we have a boiler with the gauge showing 100 pounds pressure and an engine 200 feet away that is to be operated by this steam, the pressure of the steam at the engine end of the pipe will be less than 100 pounds. Th farther away we take the engine from the boiler the greater the loss of pressure to the engine, or the greater the pressure drop.

The resistance of a piece of wire depends upon three things: First, the kind of metal in the wire. Copper offers less resistance, to the flow of current than iron. Second, the area or size of the wire. The larger the wire the less the resistance to the flow of current. Third, the length of the wire. The longer the wire the greater the resistance offered to the flow of current. The size of a wire to use in a circuit depends upon the amount of current that must flow and the length of the wire.

If two number 10 wires made of copper are run for a distance of 1,000 feet, and a lamp that consumes one-half ampere of current is connected across the ends of the wires there will be a drop in pressure in carrying the current this distance. If the pressure of the source is 110 volts the pressure of the current at the lamp will be 109 volts. This resistance offered to the flow of current is one ohm per 1,000 feet when number 10 wire is used. The two thousand feet of number 10 wire used in this case offers 2 ohms of resistance. (To find voltage drop, multiply ohms resistance by amperes flowing.) Then 2 ohms resistance times one-half ampere is equal to one volt drop. If ten of the same sized lamps are connected across the end of these wires in the place of the one lamp, the drop in pressure will be much greater. The 10 lamps will consum 5 amperes of current. Then 2 ohms times 5 amperes equals 10 volts drop. This means that the pressure across the lamps will be only 100 volts and the lamps will burn dim, due to the great drop in pressure. In this case the pressure drop is about 9%.

TABLE OF WIRE SIZES FOR AUTOMOBILE USE, FIGURED ON A 4% DROP

TABLE NO. 1 Automobile Wiring.)

Length of wire in feet.

| Number of Amperes Flowing. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 33 | 30 | 28 | 27 | 26 | 25 | 25 | 24 | 24 | 23 | 23 | 22 | 22 | 22 | 21 | 21 | 21 | 21 | 21 | 20 |
| 2 | 30 | 27 | 25 | 24 | 23 | 22 | 22 | 21 | 21 | 20 | 19 | 19 | 19 | 19 | 18 | 18 | 18 | 18 | 17 | 17 |
| 3 | 28 | 25 | 24 | 22 | 21 | 21 | 20 | 19 | 19 | 18 | 18 | 18 | 18 | 17 | 17 | 16 | 16 | 16 | 16 | 15 |
| 4 | 27 | 24 | 22 | 21 | 20 | 19 | 19 | 18 | 18 | 17 | 17 | 16 | 16 | 16 | 15 | 15 | 15 | 15 | 14 | 14 |
| 5 | 26 | 23 | 21 | 20 | 19 | 18 | 18 | 17 | 17 | 16 | 16 | 15 | 15 | 15 | 15 | 14 | 14 | 14 | 14 | 13 |
| 6 | 25 | 22 | 21 | 19 | 18 | 18 | 17 | 16 | 16 | 15 | 15 | 15 | 14 | 14 | 14 | 13 | 13 | 13 | 13 | 12 |
| 7 | 25 | 22 | 20 | 19 | 18 | 17 | 16 | 16 | 15 | 15 | 14 | 14 | 14 | 13 | 13 | 13 | 13 | 12 | 12 | 12 |
| 8 | 24 | 21 | 19 | 18 | 17 | 16 | 16 | 15 | 15 | 14 | 14 | 13 | 13 | 13 | 12 | 12 | 12 | 12 | 11 | 11 |
| 9 | 24 | 21 | 19 | 18 | 17 | 16 | 15 | 15 | 14 | 14 | 13 | 13 | 13 | 12 | 12 | 12 | 11 | 11 | 11 | 11 |
| 10 | 23 | 20 | 18 | 17 | 16 | 15 | 14 | 14 | 13 | 13 | 13 | 12 | 12 | 12 | 12 | 11 | 11 | 11 | 11 | 10 |
| 11 | 23 | 19 | 18 | 17 | 16 | 15 | 14 | 14 | 13 | 13 | 12 | 12 | 12 | 11 | 11 | 11 | 11 | 10 | 10 | 10 |
| 12 | 22 | 19 | 18 | 16 | 15 | 15 | 14 | 13 | 13 | 12 | 12 | 12 | 11 | 11 | 11 | 10 | 10 | 10 | 10 | 9 |
| 13 | 22 | 19 | 18 | 16 | 15 | 14 | 14 | 13 | 13 | 12 | 12 | 11 | 11 | 11 | 10 | 10 | 10 | 10 | 10 | 9 |
| 14 | 22 | 19 | 17 | 16 | 15 | 14 | 13 | 13 | 12 | 12 | 11 | 11 | 11 | 10 | 10 | 9 | 9 | 9 | 9 | 9 |
| 15 | 21 | 18 | 17 | 15 | 15 | 14 | 13 | 12 | 12 | 12 | 11 | 11 | 10 | 10 | 10 | 9 | 9 | 9 | 9 | 9 |
| 16 | 21 | 18 | 16 | 15 | 14 | 13 | 13 | 12 | 12 | 11 | 11 | 10 | 10 | 9 | 9 | 9 | 9 | 9 | 8 | 8 |
| 17 | 21 | 18 | 16 | 15 | 14 | 13 | 13 | 12 | 11 | 11 | 11 | 10 | 10 | 9 | 9 | 9 | 9 | 8 | 8 | 8 |
| 18 | 21 | 18 | 16 | 15 | 14 | 13 | 12 | 12 | 11 | 11 | 10 | 10 | 10 | 9 | 9 | 9 | 8 | 8 | 8 | 8 |
| 19 | 21 | 17 | 16 | 14 | 14 | 13 | 12 | 11 | 11 | 11 | 10 | 10 | 10 | 9 | 9 | 8 | 8 | 8 | 8 | 8 |
| 20 | 20 | 17 | 15 | 14 | 13 | 12 | 12 | 11 | 11 | 10 | 10 | 9 | 9 | 9 | 9 | 8 | 8 | 8 | 8 | 7 |
| 30 | 18 | 15 | 14 | 12 | 12 | 11 | 10 | 9 | 9 | 9 | 8 | 8 | 7 | 7 | 7 | 7 | 6 | 6 | 6 | 6 |
| 40 | 17 | 14 | 12 | 11 | 10 | 9 | 9 | 8 | 8 | 7 | 7 | 7 | 6 | 6 | 6 | 5 | 5 | 5 | 5 | 4 |
| 50 | 16 | 13 | 12 | 10 | 9 | 9 | 8 | 7 | 7 | 6 | 6 | 6 | 5 | 5 | 5 | 4 | 4 | 4 | 4 | 3 |
| 60 | 15 | 12 | 11 | 9 | 9 | 8 | 7 | 7 | 6 | 6 | 5 | 5 | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 3 |
| 70 | 15 | 12 | 10 | 9 | 8 | 7 | 6 | 6 | 5 | 5 | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 2 | 2 | 2 |
| 80 | 14 | 11 | 9 | 8 | 7 | 7 | 6 | 6 | 5 | 4 | 4 | 4 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 1 |
| 90 | 14 | 11 | 9 | 7 | 7 | 6 | 5 | 5 | 4 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 0 |
| 100 | 13 | 10 | 9 | 7 | 6 | 6 | 5 | 4 | 4 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 110 | 13 | 10 | 8 | 7 | 6 | 5 | 4 | 4 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 120 | 12 | 9 | 8 | 7 | 6 | 5 | 4 | 4 | 3 | 2 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 00 | 00 |
| 130 | 12 | 9 | 7 | 6 | 5 | 4 | 4 | 3 | 3 | 2 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 00 | 00 | 00 |
| 140 | 12 | 9 | 7 | 6 | 5 | 4 | 3 | 3 | 2 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 00 | 00 | 00 | 00 |
| 150 | 12 | 9 | 7 | 6 | 5 | 4 | 3 | 3 | 2 | 4 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 1 | 1 | 1 |

Size of wire to be used.

## PROPER SIZE WIRE TO USE

**When Carrying a Certain Load for a Certain Distance.**

**Distance in feet from plant to point of delivery.**

| Amperes Flowing | 25′ | 50′ | 75′ | 100′ | 150′ | 200′ | 300′ | 400′ | 500′ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| 2 | 12 | 12 | 12 | 12 | 12 | 12 | 10 | 10 | 8 |
| 3 | 12 | 12 | 12 | 12 | 12 | 10 | 10 | 8 | 6 |
| 4 | 12 | 12 | 12 | 12 | 12 | 10 | 8 | 6 | 6 |
| 5 | 12 | 12 | 12 | 12 | 10 | 8 | 8 | 6 | 4 |
| 6 | 12 | 12 | 12 | 12 | 10 | 8 | 6 | 4 | 4 |
| 7 | 12 | 12 | 12 | 10 | 8 | 8 | 6 | 4 | 4 |
| 8 | 12 | 12 | 10 | 10 | 8 | 6 | 4 | 4 | 2 |
| 9 | 12 | 12 | 10 | 10 | 8 | 6 | 4 | 4 | 2 |
| 10 | 12 | 12 | 10 | 8 | 8 | 6 | 4 | 2 | 2 |
| 11 | 12 | 12 | 10 | 8 | 6 | 6 | 4 | 2 | 2 |
| 12 | 12 | 12 | 10 | 8 | 6 | 4 | 4 | 2 | 2 |
| 13 | 12 | 10 | 8 | 8 | 6 | 4 | 2 | 2 | |
| 14 | 12 | 10 | 8 | 8 | 6 | 4 | 2 | 2 | |
| 15 | 12 | 10 | 8 | 6 | 6 | 4 | 2 | 2 | |
| 16 | 12 | 10 | 8 | 6 | 4 | 4 | 2 | | |
| 17 | 12 | 10 | 8 | 6 | 4 | 4 | 2 | | |
| 18 | 12 | 10 | 8 | 6 | 4 | 4 | 2 | | |
| 19 | 12 | 8 | 8 | 6 | 4 | 4 | 2 | | |
| 20 | 12 | 8 | 8 | 6 | 4 | 2 | 2 | | |

TABLE No. 2 (DELCO LIGHT)

## WIRE SIZE FOR 2 VOLT DROP

**Example**—What size wire should be used to transmit 6 amperes a distance of 150 feet? Opposite 6 amperes in the left hand column and under 150′ is No. 10. Therefore, No. 10 wire should be used.

**A conductor must be large enough to carry the desired amount of current to a certain point with less than 5% drop. Table No. 1 gives the correct size of wire to use in wiring motor cars with the exception of wires used in the cranking circuit. In the cranking circuit the drop should be held to not over 2%. This means to use a wire three sizes larger in the cranking circuit than given in the table.**

**Table No. 2 gives the correct size of wire to use in wiring to Delco Light systems, holding the drop to not over 2 volts.**

The left-hand vertical columns read amperes and the upper columns across the page read feet. To find the proper size of wire to use follow the upper column across the sheet until the desired number of feet is located, then follow down this column until you come to the column opposite to the number of amperes required.

For example, if 5 amperes is to be carried for a distance of 20 feet, first locate the number 20 in the top row Table No. 1) and follow down this column until you come to the column opposite 5 amperes. The number at this intersection (No. 13) is the proper size.

## GENERAL INFORMATION

Acid. Muriatic acid is used in making soldering solution. (See soldering solutions.)

Sulphuric acid is used in making solution used in a storage battery called electrolyte. (See electrolyte.)

Active material. A composition used in making the plates of a storage battery. Active material is pasted into lead grids in making the plates.

Alloy. A compound of two or more metals. Brass is a yellow alloy made of copper, zinc and tin.

Alternating current. Current that rapidly changes direction of flow in a circuit. A current that flows alternately in opposite directions.

Ammeter. An electric instrument used to indicate the rate of flow of current in a circuit. Used in testing dry cell batteries. Must not be used in testing storage batteries.

Ampere. The unit of electric current. Rate of flow of current in a circuit is measured in amperes.

Amperage. A stated number of amperes passing in a circuit.

Ampere hour. The quantity of electricity passed by one ampere of current in one hour.

Ampere hour meter. A meter that registers the flow of current through it.

Ampere turn. A single turn or winding in a coil of wire through which one ampere passes.

Anneal. The process of softening by heating and then slowly cooling. Iron wire is annealed for use in making the cores of coils used for ignition purposes.

Armature. The revolving part of a motor or generator. The part of a relay attracted by magnetism.

Armature winding. The coils of insulated wire on an armature used in a motor or generator.

Automatic cut-out. A device used to automatically open or close a circuit.

Batteries. Known as dry cells or storage batteries. Dry cells are used where a small amount of current is required at a time. Storage batteries are used to store up energy in a chemical form which can be converted into an electric form. When dry cells are exhausted they are thrown away. Storage batteries can be recharged by passing a current of electricity through them. Current may be taken from a storage battery at almost any rate desired for operating electric devices on automobiles. Short circuiting of any battery is very injurious to it.

Breaker box. The compartment of a magneto in which the primary circuit is opened and closed. This compartment contains the breaker points and a cam.

Brush. Used to make an electric contact with a moving part. They are made of carbon, wire gauze, combination of metals and carbon and of metal. Most commonly used to make a flexible contact to a commutator.

Brush arm. An arm upon which a brush is mounted. When brushes are mounted on arms more even tension can be had.

Brush arm spring. A spring used to give tension to a brush on a commutator.

Circuit. The course followed by an electric current from its source through conductors back to the starting point.

Circuit breaker. An electric device used to automatically open a circuit. Usually a relay is employed and so adjusted that when over a certain amount of current attempts to flow through it the circuit will be opened. Used to attract attention when short circuits occur and to prevent losses of current.

Circuit diagram. A drawing showing the internal circuits of pieces of electric apparatus. Showing internal circuits and wiring from one or more pieces of electric appartus to another.

Closed circuit. When a circuit is closed current can flow. When a circuit is completed it is called a closed circuit.

Closed magnetic circuit. A circuit in which lines of force travel through metal only. Placing a bar of iron or steel across the ends of a horseshoe magnet closes a magnetic circuit.

Coil. A single turn of wire of an armature to which the coils of wire are connected. The part upon which the brushes make contact.

Compass. Used to indicate directions. The needle of a compass is made of a fine piece of steel and highly magnetized. This needle will point north and south if not affected by other forces. In an ordinary sewing needle is magnetized and then dipped in oil it will float on water and will point north and south.

Condenser. Made of sheets of tin foil separated from each other and connected across places in an electric circuit where the circuit is opened. It is often used to eliminate burning of contact points. In an ignition system it is also used to assist the induction coil in increasing voltage.

Conductor. Any substance through which a current of electricity will flow.

Contacts. When two or more pieces of metal are used and the arrangement is such that when they come together a circuit is closed they are called contacts or contact points.

Core. The mass of iron or iron wires forming the interior portion of an electro-magnet or induction coil and around which wire is wound. The part that is caused to be

magnetized when current flows through the wire that surrounds it.

Direct current. Current that flows constantly in the same direction.

Distillation. An operation in which two or more liquids may be separated by boiling. Distilled water is made by boiling water, catching the steam that arises and cooling it, returning it to pure water.

Distributor. A mechanically operated device used to direct the flow of current in a number of different circuits. A distributor used in connection with an ignition system is usually a timer and distributor combined. It is so arranged that it times the flow of current in the primary circuit and distributes the high tension current to the wires that go to the spark plugs. In many distributors the same contact points used in closing the primary circuit act as an interrupte. (See interrupters.)

Electricity. The name given to an invisible agent known only by its effects and actions. We do not know what it is, but we know how to control the action of it to a great extent, and no matter how it is produced, we believe it to be one and the same thing.

Electric pressure. The pressure upon the current flowing in a circuit. This pressure is measured in volts.

Electric resistance. Anything that resists the flow of current. Large wires, low resistance. Small wires, high resistance. This resistance is measured in ohms.

Electro-magnet. If an insulated wire is wound around an iron core and current is passed through the wire, this is an electro magnet. Sometimes the wire is wound on a spool made of non-magnetic material and so arranged that the core can be inserted or withdrawn as desired. This form is known as a solenoid magnet.

Electrolyte. The solution used in a storage battery. Is generally made by mixing sulphuric acid and distilled water in proportion of 2 parts of acid to 5 parts of water. These parts are measured out by volume. An earthen vessel must be used and the solution stirred while mixing. NEVER POUR THE WATER INTO THE ACID. See Gravity.)

Energy. The power of doing work. Passing a current of electricity through a storage battery causes energy to be

stored up in a chemical form. Then this energy is taken off in an electric form. Winding a watch causes energy to be stored up in a mechanical form in the spring.

Field. A term applied to a space occupied by electricity or magnetic lines of force.

Flow of current. Flow of current is measured in amperes. Current flows under a certain number of volts pressure.

Field coil. The coil of insulated wire which surrounds the pole pieces of a motor or generator.

Foot pound. This is a unit of work or energy. The lifting of one pound one foot.

Generator. A machine which converts mechanical energy into electric energy.

Gravity. Referring to the electrolyte used in a storage battery, the gravity depends upon the proportions of water and acid. The gravity of water is 1.000 and that of chemically pure sulphuric acid is 1.840.

Grooving out micas. The separators or insulators between the segments of a commutator are made of mica. In the wear of a commutator the copper will wear faster than the mica if a soft brush is used. In this case it is necessary to groove the micas out so they will be below the surface of the copper. This is done with a file and hack saw blade. Full information on this subject will be found under care of the motor and generator.

Ground. The frame of the car is known as ground.

Ground wire. Used to connect a piece of apparatus to the frame of the car.

High tension. This term applies to high voltage.

High tension magneto. A magneto in which the means of increasing pressure (voltage) is incorporated within the machine.

High tension wire. Wire with a very heavy insulation of rubber or other good insulating material.

Horse power. The power required to lift one pound 550 feet in one second.

Hydrometer. Used to test the gravity of solution in a storage battery. A floating device with a scale inside of a

glass tube.

**Ignition coil.** An induction coil used in connection with ignition systems to assist in increasing voltage.

**Induced current.** Interrupting the flow of current in the primary circuit of an ignition system causes current to be generated into the secondary winding of the ignition coil. This is called induced current.

**Insulation.** Covering used on wires as an insulator. A material that is a non-conductor.

**Interrupter.** A device used to interrupt the flow of current in the primary circuit of an ignition system. This is necessary in order that current be generated into the secondary winding of the ignition coil or armature. The armature of a high tension magneto has both a primary and secondary winding on it. In some battery systems a vibrator is employed as an interrupter and in others a relay is used. In some systems by a mechanical means the circuit is closed and opened.

**Kilowatt.** 1,000 watts. A unit of electric power. Electric power is generally expressed in kilowatts. The watt is the 1/746 of a horse power. The kilowatt is equal to about one and one-third horse power.

**Lines of force.** If an insulated wire is wound around an iron core and current is passed through this wire, it causes the iron core to become magnetized and lines of force pass between the poles of the magnet. That is from one end of the iron core through the air to the other end.

**Line resistance.** Resistance of the wire used in completing a circuit.

**Low tension.** This term is used to indicate low voltage.

**Low tension magneto.** A magneto that has in connection with it a separate ignition coil.

**Low tension wire.** Wires used to carry currents of a low pressure (voltage). Insulation on this wire is thin compared to that of the high tension wire.

**Magnet.** A body possessing the power of attracting metals of a similar character to it. A body possessing a magnetic field.

**Magnetic attraction.** The attraction exerted by opposite poles upon each other.

Magnetic field. The region surrounding a magnet, through which lines of magnetic force act. The magnetic field is said to be comprised of lines of magnetic force.

Magnetic repulsion. The repulsion exerted by like poles against each other.

Magnetism. The peculiar properties possessed by certain substances, such as iron or steel in virtue of which they exert force of attraction or repulsion.

Magnetize. To communicate magnetism to a substance. To become magnetic.

Magneto. An alternating current generator used to produce a spark in the cylinders of a gas engine.

Molecule. Iron or steel is said to be made up of molecules. They may be considered as little magnets.

Motor. A machine used to convert electric energy into mechanical energy.

Motor generator. A machine that may be used as a motor or generator.

Multiple. When two portions of an electric circuit are so connected that the current divides, a part flowing through each portion, the circuit is said to be conected in multiple or parallel.

Negative. A term used to indicate the direction of flow of current returning to the source.

North pole. A name given to one of the poles of a magnet. The point on the earth 90 degrees from the equator, towards the north.

Ohm. The unit of electric resistance. Resistance to the flow of current is measured in ohms.

Ohm's law. Volts divided by amperes equal ohms. Volts divided by ohms equal amperes. Amperes multiplied by ohms equal volts. If any two terms are known the third can easily be found by this rule.

Open circuit. A circuit, the electrical continuity of which has been interrupted. A broken circuit.

Open condenser. A condenser in which the tin foil has been separated or broken away from the terminals.

*Overcharge.* Passing current through a storage bat-

tery after all of the acid has been forced out of the plates.

Paints. Thick liquids used to give colors to objects or to preserve them. Most paints are conductors of a current of electricity and much care must be exercised in their use around the insulations of any electric system.

Parallel. (See multiple.)

Permanent magnet. A magnet made of hardened steel that possesses magnetic powers.

Polarity. The possession of magnetic poles. Also in testing the wires of a charging circuit for polarity to ascertain the direction of flow of current, this term is used. In making this test, fill a glass with water and stir in it some salt. Then dip the ends of the wires in the solution. If it is direct current bubbles will come of the negative wire. If it is alternating current, bubbles will come off both wires.

Pole. (Magnetic). One of the ends of a magnet.

Polie piece. In many motors or generators the part that is surrounded by a field coil is called the pole piece.

Positive A term used to indicate direction of flow of current from the source.

Power. The rate at which work is done. Mechanical power is generally measured in horse power, which is equal to the lifting of 500 pounds one foot in one second.

Primary circuit. One of the circuits where the wires are larger than others in the same system and through which low pressure current flows.

Rectifier. An electric instrument used to change alternating current into direct current. One of these instruments must be used when only alternating current is available for charging batteries. We recommend the Edison vibrating rectifier.

Relay. An electro-magnet used to open or close a circuit.

Relay. Ignition.) Used as an interrupter in connection with a battery ignition system.

Relay. (Cut-out.) Used to open or close a circuit, depending upon the pressure of the current flowing through one or more of its windings.

Relay. (Circuit breaker.) Used to open a circuit and attract attention when short circuits occur in a system.